

- 6 Officer.
An authentic journal of the siege of the Havana. By an officer. To which is prefixed, a plan of the siege of the Havana, ...
London, 1762.
44p., fold. plate; 8°
Missing the half-title.
- 7 Henderson, William Augustus.
The housekeeper's instructor; or, universal family cook. Being an ample and clear display of the art of cookery in all its various branches. ... To which is added, the complete art of carving, ... The fifth edition. By William Augustus Henderson, ...
London, [1795?].
448, [20]p., plates; 8°
- 8 Derham, W.
The artificial clock-maker. A treatise of watch and clock-work, shewing to the meanest capacities the art of calculating numbers to all sorts of movements; ... Also numbers for divers movements: with the antient and modern history of clock-work; and many instruments, tables, and other matters, ... The third edition, ...
London, 1714.
[16], 140p., plates: music; 12°

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TRANSACTIONS

OF THE

ROYAL SOCIETY OF EDINBURGH.

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TRANSACTIONS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. I.



Del. J. Smith. Sculp. J. Smith.

EDINBURGH:

PRINTED FOR J. DICKSON, BOOKSELLER TO THE ROYAL SOCIETY.

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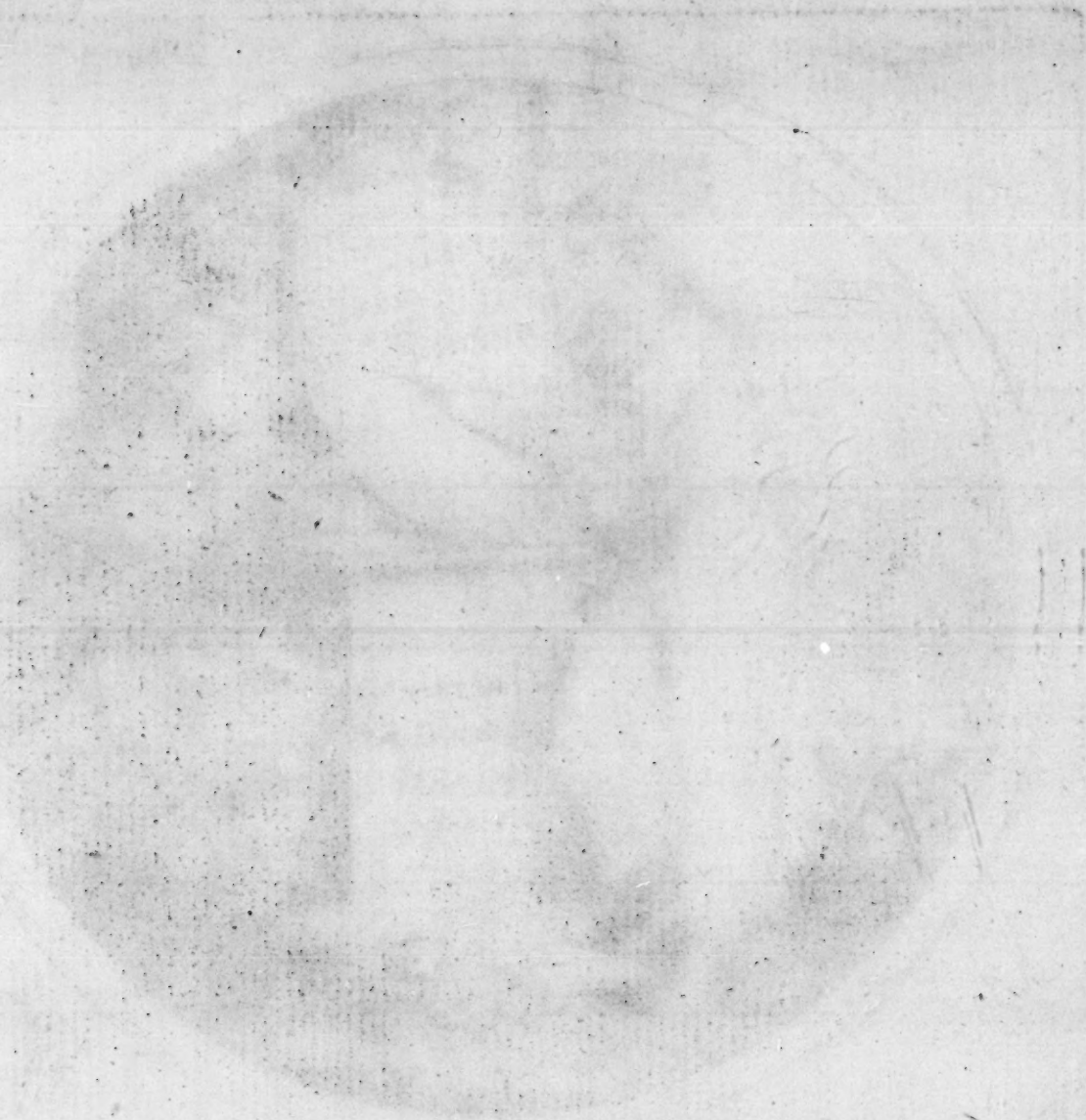
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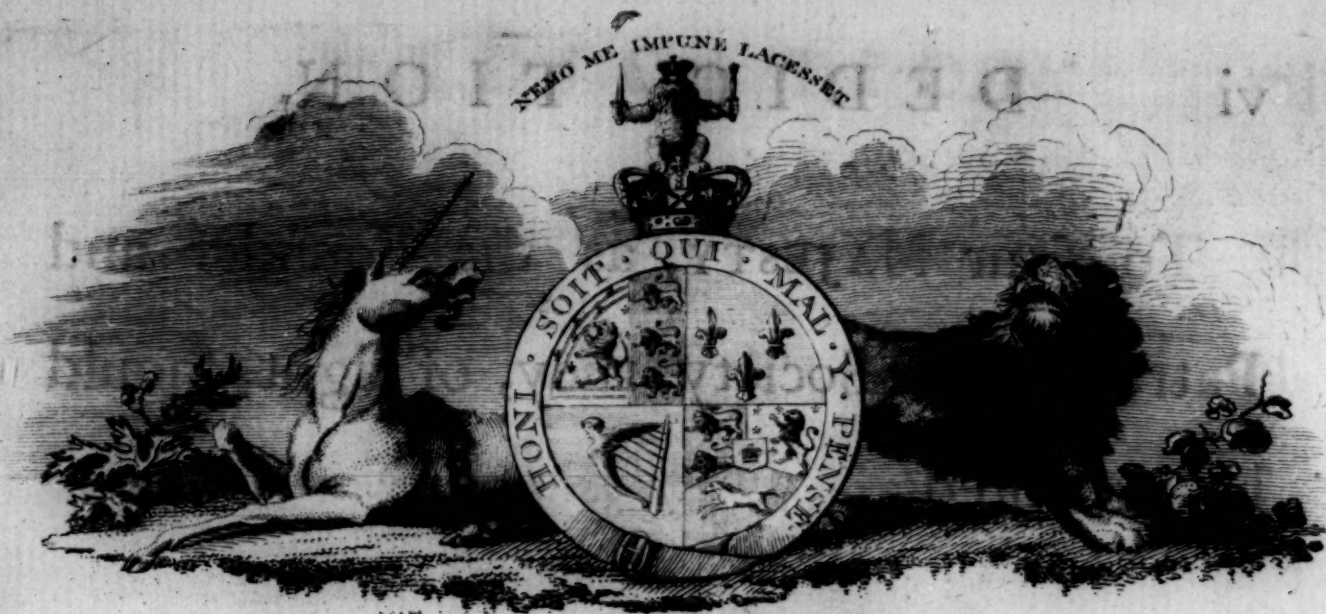
TRANSACTIONS

OF THE

ROYAL SOCIETY OF EDINBURGH

VOL. I.





TO THE
K I N G.

S I R,

I AM desired by the Members of The Royal Society of Edinburgh, humbly to request Your MAJESTY to accept the first fruits of their Philosophical and Literary labours.

To

TO Your MAJESTY, as the Founder and Patron of the Society, they, of right, should be presented.

IF they shall be found worthy of the approbation of a MONARCH, who has distinguished His Reign by the utility of His Institutions for improving the elegant Arts, as well as by the splendour and success of His undertakings to extend the knowledge of Nature, The Royal Society of Edinburgh may hope to occupy a respectable place among those Bodies of learned Men, who, by their united efforts, have contributed,

DEDICATION. vii

buted, so eminently, to the progress of
Science and of Taste in Europe. I am,
with the highest respect,

Your MAJESTY's dutiful subject,

and devoted servant,

BUCCLEUGH.

dedicated to the progress of
 science and of taste in Europe
 with the highest respect.

Your Majesty's obedient servant

and devoted servant

ROBERTSON

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*** The Society is indebted to Robert Adam, Esq; for the Design of the engraved Frontispiece.

T R A N S.

TRANSACTIONS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. I. PART I.

HISTORY OF THE SOCIETY.

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ROYAL SOCIETY OF EDINBURGH.

VOL. I. PART I.

HISTORY OF THE SOCIETY.

HISTORICAL

OF

THE SOCIETY.

THE institution of Societies of learned men, who have united their labours for the cultivation of Philosophy, or of Literature, is of an ancient date in several polished nations of Europe. It is, however, for the honour of Great Britain to have set the first example of an institution for these purposes, incorporated by charter from the Sovereign, and carrying on its researches under his patronage. A hint of this kind, to the Prince then reigning, is found in the works of Lord BACON*, who recommends, as one of the *opera verè basilica*, the establishment of Academies or Societies of learned men, who should give, from
(A) time

* Bacon de Augment. Scient. l. 2.

time to time, a regular account to the world of their researches and discoveries. It was the idea of this great philosopher, that the learned world should be united, as it were, in one immense republic, which, though consisting of many detached states, should hold a strict union and preserve a mutual intelligence with each other, in every thing that regarded the common interest. The want of this union and intelligence he laments as one of the chief obstacles to the advancement of science; and, justly considering the institution of public societies, in the different countries of Europe, under the auspices of the Sovereign, to be the best remedy for that defect, he has given, in his fanciful work of the *New Atlantis*, the delineation of a Philosophical Society, on the most extended plan, for the improvement of all arts and sciences; a work, which, though written in the language, and tinged with the colouring of romance, is full of the noblest philosophic views. The plan of Lord BACON, which met with little attention from the age in which he lived, was destined to produce its effect in a period not very distant. The scheme of a *Philosophical College*, by COWLEY, is acknowledged to have had a powerful influence in procuring the establishment of the Royal Society of London, by charter from CHARLES II.*; and COWLEY's plan is manifestly copied, in almost all its parts, from that in the *New Atlantis*. The institution of the Royal Society of London was soon followed by the establishment of the Royal Academy of Sciences at Paris; and these two have served as models to the Philosophical Academies of highest reputation in the other kingdoms of Europe.

IN Scotland, similar associations for the advancement of science and of literature have, even without the benefit of Royal patronage, and with no other support than the abilities of their members, attained to no common degree of reputation.

IN

* SPRAT'S History of the Royal Society of London, 2d edit. p. 59.

IN Edinburgh, a Society was instituted in 1731, for the improvement of medical knowledge, by collecting and publishing Essays and Observations on the various branches of Medicine and Surgery, written by the members themselves, or communicated to them. The Secretary of this Society was the elder Dr ALEXANDER MONRO, the first professor of Anatomy in the University of Edinburgh, and the founder of the medical school which has since attained to such eminence and celebrity. Under his care, the Transactions of this Society were published at different periods, in five volumes 8vo, with the title of *Medical Essays and Observations*, &c. ; a work which has undergone many editions, which has been translated into many foreign languages, and is honoured with the encomium of HALLER, as one of the most useful books in the sciences of Medicine, Anatomy and Surgery.

SOON after the publication of the above mentioned volumes of Medical Essays, viz. in 1739, the celebrated Mr MACLAURIN, professor of Mathematics in the University of Edinburgh, conceived the idea of enlarging the plan of this society, by extending it to subjects of Philosophy and Literature. The institution was accordingly new-modelled, by a printed set of laws and regulations, the number of members was increased, and they were distinguished, from that time, by the title of *The Society for improving Arts and Sciences*, or, more generally, by the title of *The Philosophical Society of Edinburgh*. They chose for their President JAMES Earl of Morton, afterwards President of the Royal Society of London : Sir JOHN CLERK of Pennycuik, one of the Barons of Exchequer, and Dr JOHN CLERK, were elected Vice-presidents ; and Mr MACLAURIN and Dr PLUMMER Secretaries of the institution. The ordinary members were some of the most distinguished men of letters in Scotland at that time.

A FEW years after the Society had received its new form, its meetings were interrupted, for a considerable space of time, by the

the disorders of the country during the rebellion in 1745; and no sooner was the public tranquillity re-established, than it suffered a severe loss by the death of Mr MACLAURIN, whose comprehensive genius, and ardour in the pursuits of science, peculiarly qualified him for conducting the business of an institution of this nature. The meetings of the Society, however, were renewed about the year 1752; and the new Secretaries, who were the celebrated Mr DAVID HUME and Dr ALEXANDER MONRO, *junior*, were directed to arrange and prepare for the press such papers as were judged worthy of being submitted to the public eye. The first volume of the Transactions of the Philosophical Society of Edinburgh was accordingly published in 1754, under the title of *Essays and Observations, Physical and Literary*; the second volume was published in 1756, and the third in 1771.

It has been always observed, that institutions of this kind have their intervals of languor, as well as their periods of brilliancy and activity. Every associated body must receive its vigour from a few zealous and spirited individuals, who find a pleasure in that species of business, which, were it left to the care of the members in general, would be often reluctantly submitted to, and always negligently executed. The temporary avocations, and, still more, the deaths of such men, have the most sensible effect on the societies to which they belonged. The principle of activity which animated them, if not utterly extinguished, remains long dormant, and a kindred genius is required to call it forth into life.

FROM causes of this kind, the Philosophical Society of Edinburgh, though its meetings were not altogether discontinued, appears to have languished for some time, till about the year 1777, when its meetings became more frequent, and, from the uncommon zeal and distinguished abilities of the late HENRY HOME, Lord KAIMES, at that time elected President of the institution,

stitution, its business was conducted with renewed ardour and success.

ABOUT the end of the year 1782, in a meeting of the Professors of the University of Edinburgh, many of whom were likewise members of the Philosophical Society, and warmly attached to its interests, a scheme was proposed by the Reverend Dr ROBERTSON, Principal of the University, for the establishment of a New Society on a more extended plan, and after the model of some of the foreign Academies, which have for their object the cultivation of every branch of science, erudition and taste. It appeared an expedient measure to solicit the Royal Patronage to an institution of this nature, which promised to be of national importance, and to request an establishment by charter from the Crown. The plan was approved and adopted; and the Philosophical Society, joining its influence as a body, in seconding the application from the University, his Majesty was most graciously pleased to incorporate THE ROYAL SOCIETY OF EDINBURGH, by the following Charter:

GEORGIUS, *Dei Gratia, Magnæ Britanniae, Franciæ, et Hiberniæ Rex, Fidei Defensor, OMNIBUS probis hominibus, ad quos præsentēs Literæ nostræ pervenerint, Salutem. QUANDOQUIDEM, Nos considerantes quod Petitio humilis Nobis oblata fuerit, a Henrico Duce de Buccleugh, Roberto Dundas Armigero, Domino Præsidente Curiae Sessionis; Jacobo Montgomery Armigero, Domino Capitali Barone Curiae Scaccarii in Scotia; Thoma Miller Armigero, Domino Justitiario Clerico; Joanne Grieve Armigero, Domino Præposito Civitatis Edinensis; Domino Alexandro Dick Baronetto; Domino Georgio Clerk Baronetto; Reverendo Gulielmo Robertson, S. S. Theologiæ Doctore, Academia Edinensis Præsecto; Gulielmo Cullen et Alexandro Monro, Medicinæ Doctores; Hugone Blair et Joanne Walker, S. Theologiæ Doctores; Adamo Ferguson, Legum Doctore, et Andrea Dalzel, Joanne Robison, et Allano Maconochie, in Academia Edinensi Professoribus; Ilay Campbell*

Campbell Armigero, Solicitatore nostro Generali pro Regno Scotia; Jacobo Hunter-Blair et Adamo Smith, Armigeris, et Joanne Maclaurin, Gulielmo Nairne, et Roberto Cullen, Armigeris, Advocatis; ab iis scilicet, atque in eorum nomine: In qua Petitione enarratur, Eruditorum hominum Societates usu compertas esse admodum idoneas ad promovendam Scientiam, et bonum de re Literaria Judicium, ubicunque gentium institutæ fuerint; Atque adeo multos esse homines, aut Loco aut Literis eminentes, qui votum diu extulerint, ut Societas Literaria Edinburgi institueretur, ad Statum illius partis Imperii nostri quæ Scotia vocatur accommodata, persuasissimum habentes ejusdem Labores et Indagationes emolumento Reipublicæ baud aspernando futuras: Quem ad finem Petitores supradictos spectantes Societatem inter se, si modo Patrocinio nostro digni haberentur, inire constituisse, eosdemque submissee sperare Nobis pro gratia nostra placiturum, ut eos in unum Corpus formemus, una cum aliis quicunque in eorum numerum sint cooptandi, ad Societatem constituendam, quæ non solum in Scientiis Matheseos, Physices, Chæmiæ, Medicinæ et Historiæ Naturalis, verum etiam in iis quæ ad Archæologiam, Philologiam et Literaturam spectant, versetur: Precantes igitur, ut iis concedamus regiam nostram Cartam, seu Literas patentes, sub Sigillo intus script. Nominantem, Constituentem, Erigentem, et Incorporantem dictos Petitores, et alios quales postea assumentur seu eligentur Socii, In unum Corpus Politicum et Corporatum, seu legalem Incorporationem, per Nomen et Titulum, et sub Ordinationibus in his postea dictis: ET NOS certiores facti Consilium Petitorum esse laudabile et dignum quod promoveatur: IGITUR Constituimus, Ereximus et Incorporavimus, sicuti Nos, regia nostra prerogativa, et Gratia speciali, pro Nobismetipsis nostrisque regiis Successoribus, per has præsentis, Constituimus, Erigimus, et Incorporamus PRÆFATOS Henricum Ducem de Buccleugh; Robertum Dundas Armigerum, Dominum Præsidem Curiae Sessionis; Jacobum Montgomery Armigerum, Dominum Capitem Baronem Curiae Scaccarii in Scotia; Thomam Miller Armigerum, Dominum Justitiarium Clericum; Joannem Grieve Armigerum, Dominum Præpositum Civitatis Edinensis; Dominum Alexandrum

Alexandrum Dick Baronettum; Dominum Georgium Clerk Baronettum; Reverendum Gulielmum Robertson, S. S. Theologiæ Doctorem, Academia Edinensis Præfektum; Gulielmum Cullen et Alexandrum Monro, Medicinæ Doctores; Hugonem Blair et Joannem Walker, S. Theologiæ Doctores; Adamum Ferguson, Legum Doctorem, et Andream Dalzel, Joannem Robison et Allanum Maconochie, in Academia Edinensi Professores; Ilay Campbell Armigerum, nostrum Solicitorem Generalem pro Regno Scotiæ; Jacobum Hunter-Blair et Adamum Smith, Armigeros, et Joannem Maclaurin, Gulielmum Nairne, et Robertum Cullen, Armigeros, Advocatos, atque alios viros quales postea assumentur seu eligentur Socii, IN UNUM CORPUS POLITICUM ET CORPORATUM, vel LEGALEM INCORPORATIONEM, per Nomen et Titulum REGALIS SOCIETATIS EDINBURGI, ad promovendas Literas et Scientiam utilem, utque talis existens, et per tale nomen Perpetuitatem habeat et Successionem; atque ut potens et capax sit capere, tenere et frui proprietate reali seu personali, et petere, Causas agere, defendere et respondere, et conveniri in Jus, trahi, defendi et responderi in omnibus seu ullis nostris Curiis Judicaturæ: ET NOS potestatem damus Petitoribus primum eorum Congressum tenendi, quarto die Lunæ mensis Junii proximi, in Bibliotheca Academia Edinensis, hora duodecima meridiana, cum potestate comperendinandi, atque, vel ad dictum Congressum, vel ad tempus in quod idem, per majorem Suffragiorum numerum eorum qui aderunt, comperendinatus fuerit, eligendi Præsidem et tot Socios quot idoneos ad complendam Societatem judicaverint; ibique, necnon ad eorum Congressus subsequentes, ordinandi Canones, ad quos Res Societatis sint administrandæ, Præsidesque et Socii sint eligendi; qui, tamen, Canones mutari vel augeri possint, majore suffragante numero Sociorum qui ad ullum Congressum Societatis aderunt, si modo quæ sunt mutanda vel adjicienda, proposita fuerint in Congressu habito uno mense ante illum Congressum ubi de his judicandum sit: ET NOS ordinamus, ut cunctæ Res antiquæ, Tabulæ publicæ, Librique Manuscripti, quos acquisiverit dicta Societas, deponantur in Bibliotheca Facultatis Juridicæ,

ridicæ, atque ut universa Corpora quæ ad Historiam Naturalem pertinent, quæque eadem Societas acquisiverit, deponantur in Musæo Academicæ Edinensis, ita ut utraque Collectio aperta sit Sociis, et e re publica sit, quantum fieri potest: ET dicti Petitores, atque ii ex quibuscunque postea constabit dicta Societas, per has Literas patentes, potestatem habebunt privatas ferendi Leges ad ejus administrationem idoneas, et in aliis rebus procedendi, agendi et faciendi, congruè cum Generali Lege et Praxi nostri Regni Scotiæ in talibus casibus. IN CUJUS REI TESTIMONIUM, præsentibus Sigillum nostrum per Unionis Tractatum custodienda. et in Scotia, Vice et Loco magni Sigilli ejusdem, utend. ordinat. appendi mandavimus: APUD Aulam nostram apud St James's, vigesimo nono die mensis Martii, anno Domini millesimo septingentesimo et octogesimo tertio, Regni que nostri anno vigesimo tertio.

1783.

Per Signaturam Manu S. D. N. Regis superscript.

June 23.
1st General
Meeting of the
Royal Society.

THE first general meeting of the Royal Society of Edinburgh was held, in terms of the above Charter, on Monday the 23d day of June 1783, and the Right Honourable THOMAS MILLER of Barskimming, Lord Justice-Clerk, was chosen President of the meeting.

IT was then unanimously resolved, That all the members of the Philosophical Society of Edinburgh should be assumed as members of the Royal Society: And it was likewise resolved, That the Lords of Council and Session, the Barons of Exchequer for Scotland, and a select number of other gentlemen, should be invited to a participation of the Society's labours.

THE meeting afterwards proceeded to establish the form or constitution of the Society, and to frame a set of regulations for its future proceedings.

Mr JOHN ROBISON, Professor of Natural Philosophy in the University of Edinburgh, was unanimously elected General Secretary, and Mr ALEXANDER KEITH, writer to the Signet, Treasurer of the Society.

THE

THE meeting was then adjourned to Monday the 4th day of August 1783.

1783.

THE Society having met, in terms of the adjournment, the Secretary gave in a list of those noblemen and gentlemen who had accepted of the invitation to become members. He also informed the meeting, that he had been directed by the Vice-President and members of the Philosophical Society of Edinburgh, to deliver their minute-book, and all such dissertations and papers as were in their Secretary's hands, to the Royal Society. The minute-book and papers were accordingly received, and given in charge to the General Secretary.

August 4.
2d General
Meeting.

THE members then considered anew the statutes and regulations which had been proposed at last meeting, and enacted a body of fundamental laws, ascertaining their constitution, and directing their future proceedings.

Laws of the So-
ciety.

IT is judged unnecessary to give a minute account of these laws. The public is interested only in what relates to the scientific proceedings of the Society, the general duties of its members, and the election of candidates.

THE Royal Society of Edinburgh consists of *Ordinary* and *Honorary* members; and the honorary places are restricted to persons residing out of Great Britain and Ireland.

THE election of new members is appointed to be made at two stated general meetings, which are to be held on the fourth Monday of January, and the fourth Monday of June.

Election of
Members.

A CANDIDATE for the place of an ordinary member must signify, by a letter addressed to one of the members, his wish to be received into the Society. He must then be publicly proposed at least a month before the day of election. If the proposal be seconded by two of the members present, his name is to be inserted in the list of candidates, and hung up

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in

in the ordinary place of meeting. The election is made by ballot, and is determined in favour of a candidate, if he shall have the votes of two thirds of those present, in a meeting consisting of at least twenty-one members.

THE general business of the Society is managed by a President, two Vice-Presidents, with a council of twelve, a General Secretary, and a Treasurer. These officers are chosen by ballot, annually, on the last Monday of November. All public deeds, whether of a civil or of a literary nature, are transacted by this board, and proceed in the name of the President or Vice-President.

It is requested and expected of each of the members, that he will favour the Society, from time to time, with such essays or observations on subjects of science, literature, or other useful knowledge, as his leisure and opportunities may render convenient.

The Society divided into two Classes.

As it was thought that the members would have a greater inducement to punctual attendance on the meetings of the Society, if they had some general intimation of the nature of the subjects which were to be considered, and made the topics of conversation, it was therefore resolved, to divide the Society into *Two Classes*, which should meet and deliberate separately.

The Physical Class.

The one of these classes is denominated the PHYSICAL CLASS, and has for its department the sciences of Mathematics, Natural Philosophy, Chemistry, Medicine, Natural History, and whatever relates to the improvement of Arts and Manufactures.

The Literary Class.

THE other is denominated the LITERARY CLASS, and has for its department Literature, Philology, History, Antiquities, and Speculative Philosophy.

EVERY

EVERY member is desired, at his admission, to intimate which of those classes he wishes to be more particularly associated with; but he is, at the same time, entitled to attend the meetings of the other class, and to take part in all its proceedings.

EACH of the classes has four Presidents and two Secretaries, who officiate by turns.

THE meetings of the Physical Class are held on the first Mondays of January, February, March, April, July, August, November and December; and the meetings of the Literary Class are held on the third Mondays of January, February, March, April, June, July, November and December, at 7 o'clock afternoon.

Times of meeting.

AT these meetings, the written essays and observations of the members of the Society, or their correspondents, are read publicly, and become the subjects of conversation. The subjects of these essays and observations are announced at a previous meeting, in order to engage the attendance of those members who may be particularly interested in them. The Author of each dissertation is likewise desired to furnish the Society with an abstract of it, to be read at the next ensuing meeting, when the conversation is renewed with increased advantage, from the knowledge previously acquired of the subject.

Business of the Meetings.

AT the same meetings are exhibited such specimens of natural or artificial curiosities, such remains of antiquity, and such experiments, as are thought worthy of the attention of the Society. All objects of natural history presented to the Society, are ordered by the Charter of the Institution to be deposited, on receipt, in the Museum of the University of Edinburgh, and all remains of antiquity, public records, or ancient manuscripts, in the Library belonging to the Faculty of Advocates at Edinburgh.

THE

THE ordinary members, whose usual residence is in the city of Edinburgh, or its immediate neighbourhood, are expected to attend regularly the monthly meetings ; and are required to defray, by an annual contribution, the current expences of the institution. The members who reside at such a distance from Edinburgh, that they cannot enjoy the advantages arising from a regular attendance on the meetings of the Society, are not subjected to any contribution for defraying its expences, but have a right to attend those meetings when occasionally in Edinburgh, and to take part in all their proceedings.

Committee for
Publication.

THE compilation of the printed transactions of the Royal Society of Edinburgh, is to be made in the following manner : The papers read at the monthly meetings, and deposited in the hands of the Secretaries of the two classes, are subjected to the review of *the Committee for publication*, which consists of the President, Vice-Presidents and Council, the General Secretary and Treasurer of the Society ; together with the Presidents and Secretaries of the two classes. This Committee makes a selection of papers, and determines the order in which they are to be published. It is not, however, to be understood, that those papers which do not appear in the Transactions of the Society, are thought unfit for the public eye. Several papers have been communicated with the sole view of furnishing an occasional entertainment to the members ; and that end being answered, have been withdrawn by their authors : Essays, observations, and cases, are often read at the meetings of the Society, in order to obtain the opinions of the members on interesting or intricate subjects : Some papers intended for a future publication have been withdrawn for the present by their authors, in order to profit by what has occurred in the conversations which the reading of the papers has suggested ; and others, of acknowledged merit, the Committee has found it necessary to reserve
for

for a subsequent volume. Nor is the publication of any paper to be considered as expressing any concurrence in opinion with the author. It only intimates that the Committee judges the paper to be worthy of public notice, on account of the useful information it contains, the hints which it may suggest, or the ingenuity which it displays.

AFTER the enactment of the Laws of the Society, the meeting proceeded to the election of the office-bearers of the ensuing year. [See the List subjoined to Part first of this volume.]

THE *Physical Class* of the Royal Society of Edinburgh met, for the first time, on the 4th of November 1783; and Dr WILLIAM CULLEN, Professor of Medicine in the University of Edinburgh, was requested to take the chair. The meeting then proceeded to the election of four Presidents and two Secretaries, for directing and recording the proceedings of this Class. [See the List of the office-bearers subjoined to Part first of this volume.] The meeting then appointed a Committee for framing regulations for conducting the business of the Physical Class.

THE *Literary Class* of the Royal Society of Edinburgh met, for the first time, on the 17th of November 1783, and the Reverend Dr ROBERTSON, Principal of the University, was requested to preside. The first business of the meeting was the election of four Presidents and two Secretaries, for directing and recording the proceedings of this Class. [See the List of the office-bearers subjoined to Part first of this volume.] The meeting then appointed a Committee for framing regulations for conducting the business of the Literary Class.

Phys. Cl. AT a meeting of the Physical Class of the Royal Society, the Reverend Dr WALKER read the first part of a paper,

1783.

August 4.
Election of the
Office-bearers.

Nov. 4.
1st Meeting of
the Physical
Class of the
Royal Society.

Nov. 17.
1st Meeting of
the Literary
Class.

Dec. 8.
Paper by Dr
Walker.

per, entitled, Experiments on the Motion of the Sap in Trees. The paper is published in this volume. [No. I. *Phyf. Cl.*]

Account of experiments on Antimony by Mr Russell.

AT the same meeting, Mr JAMES RUSSELL, surgeon, read an account of some experiments made by him on antimony. The object of these experiments was to find an easy and a cheap method of obtaining a solution of regulus of antimony in the muriatic acid, with a view to the preparation of tartar emetic, according to the directions in the last edition of the Dispensatory of the Royal College of Physicians in Edinburgh; the use of butter of antimony, as there directed, implying a very tedious, complicated, and expensive process. Mr RUSSELL endeavoured to obtain pure dephlogisticated muriatic acid in a fluid form, by adding to it the black calx of manganese, (freed from particles of iron by digestion with vitriolic acid, and afterwards calcined by heat,) and then distilling it: But he found it impossible to condense the fumes of the muriatic acid when thus dephlogisticated, (as it appeared to be by the black calx of manganese becoming white,) though he used a very long-necked retort, and had the receiver, containing water, immersed in snow; for this acid, contrary to what happens to all the others, becomes much more volatile on being dephlogisticated.

HE then tried the effect of the vapours of this dephlogisticated muriatic acid on regulus of antimony placed in the receiver, and in the neck of the retort. This succeeded to his wish; the regulus dissolving quickly and copiously. As regulus of antimony is an expensive preparation, he made a trial of crude antimony instead of it; and he found that the muriatic vapours very soon dissolved the metallic parts of it, and at last began to decompose the sulphur, as, on trial, he found they did pure flowers of sulphur. This he judged to be of little consequence to the ultimate object, as the affinity of the muriatic acid to antimony is much stronger than that of the vitriolic.

vitriolic. From a retort with some manganese in it, he distilled five ounces of muriatic acid on two ounces of crude antimony, moistened with water, raising the heat towards the end of the process, to make the sand-pot red-hot. After the process, there were found in the receiver some sulphur, some undecomposed antimony, and a complete solution of the metal in the muriatic acid. This solution had all the properties of butter of antimony; and its precipitate, either by means of water or alkalis, was exactly similar to the common one. Some tartar emetic, prepared from it, appeared, as to all its chemical properties, to be without fault; but Mr RUSSELL had not tried it medicinally. The quantity of precipitate, obtained from five ounces of acid and two of antimony, was about half an ounce. This must be perfectly free from all mixture of a mercurial salt or corrosive sublimate, which, it has been suspected, may be found in the common preparation. It may likewise be obtained with much more ease, and at less than a tenth part of the expence.

1783.

Lit. Cl. Mr ALLAN MACONCHIE, Advocate, read the first part of a Dissertation on the Origin and Structure of the ancient European Legislatures. The Dissertation is printed in this volume. [No. I. *Lit. Cl.*]

Dec. 15.
Dissertation by
Mr Macon-
chie.

Phys. Cl. Dr WALKER read the continuation of his paper on the motion of the Sap in Trees. [No. I. *Phys. Cl.*]

1784.

Jan. 5.
Dr Walker on
the sap of Trees.

Dr ROEBUCK read some Observations on the ripening and filling of Corn.

SUMMER 1782 having been remarkably cold and unfavourable, the harvest was very late, and much of the grain, especially oats, was green even in October. In the beginning of October, the cold was so great, that, in one night, there was produced on ponds near Kinneil, in the neighbourhood of Borrowstounness,

Dr Roebuck on
the filling of
corn.

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rowstounness,

1784.

stounness, ice three quarters of an inch thick. It was apprehended by many farmers, that such a degree of cold would effectually prevent the further filling and ripening of their corn. In order to ascertain this point, Dr ROEBUCK selected several stalks of oats, of nearly equal fulness, and immediately cut those which, on the most attentive comparison, appeared the best, and marked the others, but allowed them to remain in the field fourteen days longer; at the end of which time, they too were cut, and kept in a dry room for ten days. The grains of each parcel were then weighed; when eleven of the grains which had been left standing in the field, were found to be equal in weight to thirty of the grains which had been cut a fortnight sooner, though even the best of the grains were far from being ripe. During that fortnight, (*viz.* from October 7. to October 21.) the average heat, according to FAHRENHEIT'S thermometer, which was observed every day at 8 o'clock in the morning and 6 in the evening, was a little above 43. Dr ROEBUCK observes, that this ripening and filling of corn in so low a temperature, should be the less surprising to us, when we reflect, that seed-corn will vegetate in the same degree of heat; and he draws an important inference from his observation, *viz.* That farmers should be cautious of cutting down their unripe corn, on the supposition, that, in a cold autumn, it could fill no more.

Jan. 5.
Dr Blane on
the diseases of
the fleet.

Mr Professor DUGALD STEWART read the first part of a paper, communicated by Dr BLANE, Physician to the Fleet lately in the West Indies, giving an account of the Diseases in that fleet in 1782 and 1783. It is unnecessary to give here any abstract of this paper, as the substance of it is published by Dr BLANE in his *Observations on the Diseases of Seamen*.

Jan. 23.
Mr T. Robertson on inflection
in languages.

Lit. Cl. The Reverend Mr THOMAS ROBERTSON, minister of Dalmeny, read the first part of a Dissertation on the Theory of
of

of Inflection in Languages. This paper, and its continuation, which was read at the next meeting of the Literary Class, forming a detached chapter of a work composed by Mr ROBERTSON on the *Theory and History of Languages*, which he intends to offer to the public in a future volume of his *Enquiry into the Fine Arts*; it was, on that account, judged improper to present it here in a mutilated or imperfect form.

1784.

A GENERAL meeting of the Royal Society was held for the election of Members.

Jan. 26.
Gen. Meeting.

Phys. Cl. Mr Professor DUGALD STEWART read the remainder of Dr BLANE's Paper on the Diseases of the Fleet in the West Indies in 1782 and 1783. [See *supra*, Jan. 5. 1784.]

Feb. 2.
Dr Blane on the
diseases of the
fleet.

Dr HUTTON read the first part of a Dissertation, entitled, The Theory of Rain, which is printed in this volume. [No. II. *Phys. Cl.*]

Dr Hutton's
theory of rain.

Dr WALKER read a paper, communicated by the Earl of DUNDONALD, containing an account of a new method, invented by his Lordship, for purifying sea-salt. His Lordship, who was present, added, *viva voce*, some observations on the subject, which the Society requested he would communicate in writing at a subsequent meeting.

Earl of Dundonald
on sea-salt.

THE Earl of DUNDONALD's process for purifying sea-salt proceeded upon this observation, That the common sea-salt possesses a considerable mixture of ingredients, which render it, in a great degree, unfit for preserving victuals. These ingredients appear, by experiment, to be nauseous, bitter and cathartic salts, having an earthy basis, (magnesia salita and magnesia vitriolata or Epsom salt) which are intimately mixed with the proper sea-salt.

To purify common salt, by dissolving it in water, decomposing the bitter salts, and precipitating their earthy basis, by adding a fixed alkali, whether fossil or vegetable, is a tedious process, and by far too expensive to be employed for economical or mercantile purposes. It is even imperfect; as it is almost impossible, after that process, to separate from the sea-salt the Glauber salt, or vitriolated tartar, or salt of Sylvius, which are produced according as the fossil or vegetable alkali is used.

Lord DUNDONALD observed, That hot water saturated with sea-salt, will still dissolve a great part of the bitter earthy salts. His method, therefore, of purifying the common salt from these bitter salts is, To take a conical vessel, having a hole in the small end of it, which is to be undermost; to place it, filled with common salt, in a moderate heat; to take one twentieth part of the salt contained in it, and putting it in an iron pan, to dissolve it in its proper proportion of water, so that the water shall be completely saturated with the salt; and then to pour this solution boiling hot on the salt in the conical vessel, which is to be purified. The boiling water being already saturated with sea-salt, will dissolve no more of it, but will dissolve much of the bitter earthy salts; and this solution will gradually drop out at the hole in the bottom of the cone. When it ceases to drop, the same process is to be repeated by means of fresh portions of the same parcel of salt, already partly purified, till it be brought to the required degree of purity. Lord DUNDONALD reckons, that three such washings make the common salt of this country purer than any foreign salt; that each washing makes it $4\frac{1}{2}$ times purer than before; so that (disregarding fractions) after the second washing it will be 20 times, after the third 91 times, after the fourth 410 times, and after the fifth 1845 times purer than at first.

THE superiority of salt thus purified to common salt, is equally obvious to the taste, and by its effect in preserving fish,
flesh

flesh and butter; for it hath been often and carefully tried. Lord DUNDONALD conceives, that the simplicity, facility and cheapness of this method of purifying salt should recommend it to common practice, as it is an object of great public importance. He adds, that as all salt made by boiling has a portion of uncombined magnesia mixed with it, it is proper to add a little muriatic acid to the first brine poured on the salt, in order to dissolve the magnesia, and carry it off.

1784.

Lit. Cl. The Reverend Mr THOMAS ROBERTSON, minister of Dalmeny, read the remainder of the Essay begun by him, January 23. on the Theory of Inflection in Languages.

Feb. 16.
Mr T. Robertson on inflection in languages.

Mr JOHN MACLAURIN, Advocate, read a Dissertation to prove that Troy was not taken by the Greeks. This Dissertation is published in this volume. [No. II. *Lit. Cl.*]

Mr MacLaurin on the siege of Troy.

Phyf. Cl. The Reverend Mr JOHN PLAYFAIR read the first part of an Essay on the Causes which affect the Accuracy of Barometrical Measurements; which is published in this volume. [No. III. *Phyf. Cl.*]

March 1.
Mr Playfair on barometrical measurements.

At this meeting Dr ALEXANDER MONRO was elected a President of the Physical Class, in the room of Sir GEORGE CLERK-MAXWELL, Baronet, deceased.

Lit. Cl. Mr Professor DUGALD STEWART read an Essay on the Idea of Cause and Effect, and on the Object of Natural Philosophy. This Essay the author afterwards withdrew, on account of its connection with other papers which he did not chuse to publish at present.

March 15.
Mr D. Stewart on cause and effect.

Mr Professor DALZEL, one of the Secretaries of the Literary Class, read a short biographical Account of the deceased Dr WILLIAM LOTHIAN, the first member whom the Society had

Biographical account of Dr Lothian.

1784.

had the misfortune to lose. Having found it to be the general opinion of those members with whom he had an opportunity of conversing upon the subject, that such biographical accounts would form a proper appendix to the historical part of these Transactions, he had prepared this brief detail, preceded by some general observations, as an introduction to future accounts of the same kind. The plan was approved of by the Society; and the Reader will find this Essay followed by others of a similar nature, forming an appendix to the historical part of this volume.

April 12.
Mr Greenfield
on negative
quantities in
algebra.

Phyf. Cl. THE Reverend Mr WILLIAM GREENFIELD read a paper on the use of Negative Quantities, in the Solution of Problems by Algebraic Equations; which is published in this volume. [No. IV. *Phyf. Cl.*]

Dr Hutton's
theory of rain.

Dr HUTTON read the continuation of his paper on the Theory of Rain, published in this volume. [No. II. *Phyf. Cl.*]

Earl of Dundonald
on sea-salt.

Dr WALKER read a letter from the Earl of DUNDONALD, giving an account of some further experiments on the purification of sea-salt, which his Lordship communicated in compliance with the request of the Society, at their meeting in February. The substance of the Earl's observations will best appear from the following table. Each portion of salt was purified by four washings, according to the method formerly described.

T A B L E.

1784.

T A B L E.									
Salt employed.			Purified Salt.			Magnesia falita. Magn. vitriol.			
lb.	oz.		lb.	oz.		lb.	oz.		
Salt hot from the pan first drawn,	56	00	contained of	49	00	and of	6	05	$\frac{1}{9}$ of salt employed.
Salt hot from the pan last drawn,	56	00		33	09		22	06	$\frac{2}{3}$ Ditto.
Medium of the above,	56	00		41	04		14	05	$\frac{1}{4}$ Ditto.
Salt 6 weeks old,	56	00		47	00		7	00	$\frac{1}{8}$ Ditto.
Salt first drawn, drip- ped 24 hours,	56	00	contained of	52	12	and of	3	00	$\frac{1}{8}$ Ditto.
Salt last drawn, drip- ped 24 hours,	56	00		44	08		11	00	$\frac{1}{5}$ Ditto.
Medium of the two last,	56	00		48	10		7	00	$\frac{1}{8}$ Ditto.
Spanish great Salt,	10	00		9	15 $\frac{1}{2}$		00	00 $\frac{1}{2}$	$\frac{1}{840}$ Ditto.
Basket fine Salt,	3	00		3	00		00	00	

Dr CULLEN delivered to the Society five volumes written by Dr SAMOILOWITZ of St Petersburg, presented at the request of the Author, to the Royal Society of Edinburgh. The titles of these are to be found in the list of Donations, at the end of Part I. of this volume.

Books from Dr
Samoilowitz.

Lit. Cl. Dr JAMES ANDERSON read observations on a peculiarity in the English language, usually called a *Genitive Case*.

Dr ANDERSON is of opinion, that the English noun admits of no inflection by cases, and therefore that the term *genitive case* is improper. He contends that the addition of the letter *s* with an apostrophe, to a noun, as *John's staff*, is not an inflection of the noun, and therefore cannot be termed a Case. He affirms that when a noun undergoes a change of this sort, it ceases to be itself a noun, and becomes immediately a definitive; the office of which is to limit and render more precise the general meaning of another noun, with which it is necessarily connected. Thus the general word *staff* has its meaning limited, by the prefixing

April 19.
Dr Anderson
on the English
genitive.

1784.

prefixing of the definitive *John's*. He further observes, however, that all English nouns do not admit of this conversion into definitives. The names of animated beings, or corporeal objects, he considers as readily susceptible of such a change; but such nouns as signify abstract ideas, as *holiness*, *diligence*, *whiteness*, he considers as incapable of being thus convertible into definitives. He concludes, by recommending to grammarians, as an object worthy of investigation, the ascertaining the difference betwixt such definitives and adjectives, to which they bear a near resemblance.

Mr Hill's essay
on historical
composition.

Mr Professor JOHN HILL read the first part of an Essay on the Principles of Historical Composition; with an Application of these Principles to the Writings of TACITUS. The Essay is printed in this volume. [No. IV. *Lit. Cl.*]

Ode of Collins
on the superstitions
of the
Highlands.

THE Reverend Dr ALEXANDER CARLYLE read a Poem composed by the late Mr WILLIAM COLLINS, on the Superstitions of the Highlands of Scotland, addressed to JOHN HOME, Esq; author of *Douglas*, &c. being the Ode mentioned by Dr SAMUEL JOHNSON in his life of COLLINS, which the biographer there gives up for lost. An authentic copy of this beautiful Poem, from the manuscript in Mr COLLINS's hand-writing, is printed in this volume, preceded by a particular account of the manner in which it has been preserved and discovered. [No. III. *Lit. Cl.*]

June 5.
Mr Wilson's ex-
periments, &c.
on cold.

Phyf. Cl. Dr WALKER, one of the Secretaries of the Physical Class, read a paper by Mr PATRICK WILSON, Professor of Astronomy in the University of Glasgow, containing Experiments and Observations on a remarkable Cold which accompanies the Separation of Hoar-frost from a clear Air. The paper is published in this volume. [No. V. *Phyf. Cl.*]

Mr

Mr JOHN CLERK *junior* of Eldin, Advocate, read a short biographical account of Sir GEORGE CLERK-MAXWELL of Pennycuick, Baronet, late President of the Physical Class of the Royal Society of Edinburgh. This account is printed in the Appendix to the historical part of this volume.

1784.

Biographical
account of Sir
George Clerk,
Baronet.

Lit. Cl. Mr ALEXANDER FRASER-TYTLER, one of the Secretaries of the Literary Class, read an Essay, written by Mr Professor RICHARDSON of Glasgow, on the Ancient or Dramatic Form of Historical Composition; which is printed in this volume. [No. V. *Lit. Cl.*]

June 21.

Mr Richardson
on historical
composition.

Mr Professor DALZEL, the other Secretary of the Literary Class, read a paper, written by Mr Professor HUNTER of St Andrew's, entitled, A Grammatical Essay on the Nature, Import and Effect of certain Conjunctions. The Essay is printed in this volume. [No. VI. *Lit. Cl.*]

Mr Hunter on
certain con-
junctions.

A GENERAL meeting of the Royal Society was held for the election of general Office-bearers for the ensuing year; when his Grace the Duke of BUCCLEUGH was re-elected President, and the Right Honourable Lord JUSTICE-CLERK, and the Right Honourable HENRY DUNDAS of Melville, Vice-Presidents. The General Secretary and Treasurer of the preceding year were continued in office.

June 28.

General meet-
ing.

Phyf. Cl. Dr BLACK read a paper, communicated by Dr JOHN GRIEVE, late Physician to the Russian army, containing an Account of the Method of making a Wine, called by the Tartars *Koumifs*. The paper is published in this volume. [No. VI. *Phyf. Cl.*]

July 12.

Dr Grieve on
Koumifs.

THERE were also read two Medical Cafes, communicated by Dr MUDIE, Physician at Montrose; the one, An Instance of a
(D) complete

Medical cafes.

1784.

complete and permanent Cure in Ascites ; the other, A Case of severe nervous symptoms occurring from a slight superficial wound.

July 19.
Mr Maconochie
on the European
legislatures.

Lit. Cl. Mr ALLAN MACONOCHE, Advocate, read the remainder of his Dissertation on the Ancient European Legislatures ; which is printed in this volume. [No. I. and No. VII. *Lit. Cl.*]

August 2.
Dr Anderson
on cast iron.

Phys. Cl. Dr JAMES ANDERSON read a paper on some oeconomical uses to which cast iron may be applied. He observed, That, in several mechanic arts, masses of great weight, size and strength, are required for bruising or grinding various substances ; that it is often difficult to procure stones of sufficient size and strength for these purposes ; that cast iron, though proper in point of strength, and easily made of almost any size or shape, is sometimes inconvenient from its weight, and is, for many purposes, too expensive. He proposed, therefore, that, instead of pure iron, the moulds in which such masses are to be cast should be nearly filled with stones, or what would be still better, with bricks, as these could be easily moulded into the exact shape required ; a proper space being left for an axle where needed, and an interstice between the outermost of them and the mould ; that then melted iron should be poured in to fill up every chink. This iron, cooling and consolidating, will unite or cement the stones or bricks firmly together, and cover them with an uniform surface of metal. Thus, Dr ANDERSON thinks, that masses of any size, shape and weight, and of sufficient strength, may be procured at a cheap rate ; as a very small quantity of metal would be sufficient for a cement and coating to the stones or bricks.

IN the same way, the Doctor thinks many architectural ornaments might be made very cheap and very durable ; and he suggests the application of this method to the important purpose

pose of bridge-building, where very large stones are often required for the construction of arches. Instead of such large stones, he proposes to use compound masses, such as those above described, cemented with iron, and exactly moulded, so as to form, if required, an entire rib of an arch without a fissure; and he thinks that, in this way, a number of arches might be accurately and firmly put together.

1784.

Mr ROBISON, General Secretary, read a paper, communicated by the Reverend Mr THOMAS ELLIOT, Minister of Cavers, containing an Improvement on the Method of correcting the observed Distance of the Moon from the Sun or a Fixed Star. The paper is published in this volume. [No. VII. *Phys. Cl.*]

Mr Elliot's astronomical problem.

THERE was likewise read an account, by Dr ANDREW DUNCAN, of a case of obstinate *singultus*, in which the best effects had been produced by the use of vitriolic acid. A gentleman, in the 73d year of his age, was seized with a violent hiccough, which continued without intermission for several hours. Dr DUNCAN prescribed for him a mixture containing a drachm of *acidum vitriolicum tenue*, united with four ounces of mint-water, of which a table-spoonful was to be taken every half hour. The first dose put a stop to the *singultus*. About twelve hours afterwards, there was a return of the fit; which, however, yielded instantly to a second spoonful of the mixture; nor was there afterwards any occasion to repeat the dose.

Medical cases.

Lit. Cl. Dr GREGORY read the Introduction to an Essay towards an Investigation of the exact Import and Extent of the common Notion of the Relation of Cause and Effect in Physics, and of the real Nature of that Relation. Parts of the Essay itself were afterwards read by him at several subsequent meetings of the Literary Class; but he did not incline, that either the

Nov. 15.
Dr Gregory's essay on cause and effect.

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Essay

1784.

Essay itself, or any abstract of it, should appear in this volume of the Society's Transactions.

Nov. 29.
General meeting.

A GENERAL meeting was held for the election of the Office-bearers of the Classes. [See the List subjoined to Part I. of this volume.]

Dec. 6.
Dr Walker on
the sap of trees.

Phyf. Cl. Dr WALKER read the concluding part of his paper on the Motion of the Sap in Trees, which is published in this volume. [No. I. *Phyf. Cl.*]

Mr Fleming on
Loch Tay.

THE Reverend Mr PLAYFAIR read a letter from the Reverend Mr THOMAS FLEMING, Minister of Kenmore, giving an Account of an unusual Agitation in the Waters of Loch Tay, on the 12th of September last. The letter is published in this volume. [No. VIII. *Phyf. Cl.*]

Mr Wilson on
the solar system.

Mr JOHN ROBISON, General Secretary, informed the Society, that, a few days ago, Mr JAMES RUSSELL, one of the members, had offered to him the perusal of a paper, written by a friend, and containing some thoughts on a method for discovering by observation, whether the centre of the Solar System was in motion; with other interesting matters in astronomy. Mr ROBISON, recollecting that Mr PATRICK WILSON, assistant Professor of Astronomy at Glasgow, had long ago communicated to him in conversation, some curious speculations on this subject, told Mr RUSSELL, that, before perusing his friend's paper, he would write an account of what he could recollect of Mr WILSON's speculation on that subject. This account he now laid before the Society, in order to ascertain the title to originality or priority, in any thing which may have occurred to both of these Gentlemen.

THE sum of this account is, That about the year 1767 or 1768, Mr WILSON entertained an opinion that the aberration
of

of the fixed stars indicated the proportion between the orbital velocity of the earth, and the velocity of light in the vitreous humour of the eye. This opinion soon led him into various discussions, and, in particular, made him suppose, that the aberration of the fixed stars, when determined by observations made with a telescope filled with water, would be different from the aberration determined by observations made with a common telescope. Mr WILSON has given an account of some important and unexpected consequences resulting from these speculations, in the Philosophical Transactions of London. About the year 1775 or 1776, Mr WILSON began to entertain an opinion that the centre of the solar system was in motion, and in 1777, communicated to Mr ROBISON, and others, a paper on this subject. The water-telescope was, by this time, become familiar to his thoughts; and it occurred to him, that it might be employed for deciding this question, and even for determining the direction and velocity of this motion; by means of the difference between the observed aberration of the fixed stars and the aberration which should result from the earth's orbital motion alone. But various objections and difficulties occurred in the prosecution of this attempt, and Mr WILSON soon after thought of another method.

If the earth be carried, with a great velocity, towards a fixed star, whose rays are made to deviate a little by an achromatic prism, it will follow, that a constant angle of incidence will give different angles of total deviation, according to the velocity of the motion; and this difference will be both real and apparent. Therefore,

1. LET the telescope of a meridional quadrant be furnished with a prism, refracting a few degrees in altitude. Search, by meridional observations, for such stars as exhibit altitudes inconsistent with Dr BRADLY's aberrations: The differences will indicate an aberration caused by a motion of the earth, different from its orbital motion round the sun.

2. FURNISH

1784.

2. FURNISH a telescope with a plain mirror, inclined to its axis in an angle of 45° , and a series of achromatic prisms refracting 90° . Suppose the telescope to be directed to a point of the heavens, 90° distant from a star which is viewed through it. Suppose also the earth to be at rest, and the images of this star, formed by the refracted and by the reflected light, to coincide. Then suppose the earth to be in motion towards this star: The images will separate, both on account of a change in the total deviation of the refracted light, and also on account of a transverse aberration, to which the refracted image is liable, by the motion of the telescope.

3. If a long achromatic telescope be directed to a fixed star, towards which the earth is moving, the focal distance of the telescope will be lengthened. The augmentation will indeed be very small, but Mr WILSON has fallen upon very ingenious methods of increasing it, so as to make it become sensible.

Dec. 20.
Essay by Mr
Dalzel.

Lit. Cl. Mr Professor DALZEL read an Essay towards an Explanation of the Pleasure arising from certain Scenes, Representations and Descriptions of Distress: But he did not incline that the Essay, or any account of it, should be given in this volume.

1785.
Jan. 3.
Mr Playfair on
barometrical
measurements.

Phyf. Cl. The Reverend Mr JOHN PLAYFAIR read the second part of his Paper, on the Causes that affect the Accuracy of Barometrical Measurements, published in this volume. [No. III. *Phyf. Cl.*]

Dr Blane's ac-
count of the
hurricane at
Barbadoes.

Dr GREGORY read a paper communicated by Dr BLANE, giving an Account of the Hurricane at Barbadoes on the 10th of October 1780.

THERE had been nothing that could be called a hurricane felt at Barbadoes for more than a century before 1780, so that the

the inhabitants began to think themselves exempt from such calamities, and accordingly had no edifices of sufficient strength to withstand the force of a hurricane.

ON the 9th of October 1780, it began to blow hard at Barbadoes; but it was not apprehended till next day that there would be any thing more than such a gale as often happens at that season. But, on the evening of the 10th, the wind rose to a prodigious degree of violence.

AT 8 o'clock it began to make impression on the houses, by tearing off the roofs, and overthrowing some of the walls. The hurricane was thought to be at its greatest height at midnight, but did not abate considerably till 8 o'clock next morning. The ravage made during this night, on every object of nature and art, was complete and dreadful. The inhabitants, without distinction of age, sex, or condition, were driven from their houses, for fear of being buried in the ruins of them, and were obliged to pass the night in the fields, exposed to the impetuous wind, to the cold, which was very remarkable, considering the climate, to incessant torrents of rain, and to the terrors of thunder and lightning, which were violent and almost constant.

MULTITUDES perished, either by clinging too long to the buildings for shelter, in attempting to save what was valuable, or by unavoidable accidents from the falling of walls, roofs, and furniture, the materials of which were projected to great distances. The number of lives lost was estimated from returns made to the Governor, at more than 3000; but several parishes had given no returns.

By the violence of the wind, the bodies of men and cattle were often lifted from the ground, and carried for several yards.

ALL the fruits of the earth then standing were destroyed, most of the trees on the island were torn up by the roots, and many of them were stripped of their bark.

ALL

ALL the houses on the island suffered more or less. Many of the private houses were levelled with the ground, all of them unroofed, and the whole of their carpenter-work and furniture destroyed. The large elegant church of Bridgetown was reduced to a heap of ruins.

THE sea rose so high as to destroy the Fort, carrying the great guns many yards from their platform, and demolishing the houses near the beach. A ship was driven on shore against one of the buildings of the naval hospital, which, by this shock, and the impetuosity of the wind and sea, was entirely destroyed and swept away. The Mole-head was swept away, and ridges of coral rock were thrown up, which still remain above the surface of the water: But the harbour and road have, upon the whole, been improved, being deepened in some places six feet, in others as many fathoms; and the anchoring ground in the road is much better, by the crust of coral, which had been the growth of ages, being torn up, and leaving a soft oozy bottom. Many shells and fish were thrown on shore, which had been heretofore unknown.

THE sufferings and losses by sea were also great and calamitous. The wind was too violent for any ship to ride it out, and they all pushed to sea, where most of them perished by the mere violence of the weather, without being driven any where on shore. Out of twelve of his Majesty's ships of war that were exposed to it, five have been totally lost; and out of the crews of these, not more than ten or twelve persons have been saved.

Dr BLANE was satisfied, both from what he had an opportunity of observing himself, and from the testimony of those who had been present during the hurricane, that an earthquake attended it; and he is convinced that it is not a vulgar prejudice or error to suppose, that in hurricanes a concussion of the earth does occur different from what can proceed from the mechanical impetus of the wind. The flags in the floor of the Great Church,
at

at Bridgetown were set at angles to each other, though they were sheltered from the wind, and nothing had fallen on them that could produce such an effect; casks had changed their position in cellars below ground; masses of rock were removed, which the mere force of air and water did not seem capable of effecting; and there were chasms in the earth, which seemed to indicate some internal agitation. The inhabitants, both of Barbadoes and St Lucia, felt the earthquake plainly; and at St Lucia the earthquake happened some hours after the greatest severity of the gale.

THIS hurricane chiefly affected Barbadoes, (which is in latitude 13°) the middle Caribbee islands, Martinique, St Lucia, and St Vincent's. It was felt, but very slightly, at Antigua, St Christopher's, the Virgin islands, and at Grenada. At Tobago, they had rough weather at the time, which did no material damage. It is remarkable, that the more northern West India islands, from latitude 17° to the tropic, are seldom exempt from hurricanes, for more than seven or eight years together. At Barbadoes, it has been already observed, there had been nothing of this kind for above a century.

THE extent of this hurricane, from north to south, was pretty well ascertained by the accounts from the different islands already mentioned. But there were no means of ascertaining, with equal accuracy, how far it extended from east to west. A ship that arrived at Barbadoes six days after, had a gale of wind about the time of the hurricane, which was not particularly violent, and was remarkable only for this, that the wind blew all round the compass; a circumstance which distinguishes the hurricane from all other gales within the tropics; the course of nature being so far inverted, that the direction of the trade-winds, at other times constant, is not then observed. At Barbadoes, indeed, the greater part of the hurricane was from the N. E.; but an hour or two after midnight, it was, for a little

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time,

time, due W. and was more or less from all the intermediate points. In places but a few miles distant, people disagreed in their accounts of its violence and direction at the same point of time. It was very irregular in these respects at other places; for on the island of St Lucia they had it not at any time from the west; but the Montague and Ajax, the ships that were driven from that island, had it from all points.

THE progress of it westward was very slow, considering the violence of the wind. This, Dr BLANE thinks, was owing to the various directions in which it blew. At St Vincent and St Lucia, which are not above twenty leagues to leeward of Barbadoes, it was thirteen or fourteen hours later in coming on, and was not near so violent. At St Domingo they had it in a still less degree on the 13th and 14th of October. It has since appeared, that there was in England the most violent storm that has been known for many years, the very day of the hurricane at Barbadoes.

It was remarked, that the ships which put before the wind during the hurricane, were not carried with the velocity which might have been expected from the violence of it. A merchant-ship, with the crew on board, was driven from her anchors at Barbadoes, all the compasses were broken, and, after tossing about for two days and two nights, the people found themselves at the mouth of Carlisle bay, the very point whence they set out, at a time when they might reasonably have supposed themselves 100 leagues from it.

THERE was much lightning during the hurricane, chiefly in large sheets and steady blazes, and little of the forked and darting kind. At St Lucia, there was much of what the French called *feu de St Elme*, which Dr BLANE supposes to be the *ignis fatuus*.

THERE was in the N. E. an Aurora Borealis, an unusual appearance in the West Indies.

DURING

DURING the whole night, a rumbling noise was heard in the sky, now and then interrupted by a momentary pause. There were no observations made, either with the thermometer or barometer; but the wind was remarkably cold. Dr BLANE was informed by Dr WARNER of Antigua, that, during another hurricane which happened at that island, the barometer, near the level of the sea, fell to $27\frac{2}{8}$. It is known, that, in the West Indies, the barometer stands, with little variation, somewhere between 29 and 30.

THE influence of the hurricane on peoples health was very remarkable. Instead of producing sickness, it seemed to have the very opposite effect. There was less sickness after, than there had been before it; and most of those who were sick at the time of it were benefited by it, except the very old and delicate, who suffered, either from mechanical violence, or the subsequent want of shelter. It had a visible good effect on the diseases of the climate, fevers and fluxes. Chronic diarrhoeas, the consequence of dysenteries, were also cured by it. But the diseases on which it operated most visibly and sensibly were pulmonic complaints. Some recent cases of phthisis, and even the acute state of pleurisy, were cured by it. Nay, in the more advanced and incurable state of phthisis, the hectic fever was, in a great measure, removed, and a temporary alleviation at least procured. Dr BLANE mentioned particularly the case of a lady of his acquaintance, who was ill of a pleurisy at the time of the hurricane, and passed more than ten hours in the open air, sitting generally in a plash of water from the rain that fell; she had no more of her complaint, nor any return of it; and Dr BLANE saw her a few weeks after in better looks and in a better general state of health than she had enjoyed for a great while before. It was a general observation, that people had remarkably keen appetites for some days after the hurricane; and many people, who used to be thin and fallow, Dr BLANE saw looking fresh and plump a few weeks after it,

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though

1784.

though the unhealthy rainy season was there hardly over. These facts, which appear so very wonderful, Dr BLANE mentions with confidence, they being confirmed by a concurrence of testimony, and, in some measure, by his own observation.

Register of the
weather at
Brånxholm.

Dr WALKER presented and read the title of a paper, communicated by his Grace the Duke of BUCCLEUGH, President of the Society, containing a Register of the Quantity of Rain that fell, the height of the Barometer and Thermometer, and the general bearing of the Wind at Brånxholm for ten years, ending December 31. 1783. The Register is published in this volume. [No. IX. *Phyf. Cl.*]

1785.

Jan. 17.
Mr Frazer-Tyt-
ler on the Scan-
dinavian na-
tions.

Lit. Cl. Mr ALEXANDER FRASER-TYTTLER read a Dissertation on the Character, Manners and Genius of the Ancient Scandinavian Nations. He did not incline that the Dissertation, or any abstract of it, should be published.

Jan. 24.
Gen. Meeting.

A GENERAL meeting of the Royal Society was held for the election of Members.

Donations.

Dr WALKER laid before the meeting a collection of specimens of natural history, and other curiosities, which had been presented to the Royal Society. These are enumerated in the List of Donations, printed at the end of Part I. of this volume.

Feb. 21.
Mr Hill on hi-
storical compo-
sition.

Lit. Cl. Mr Professor JOHN HILL read the remainder of his Essay on Historical Composition, published in this volume. [No. IV. and VIII. *Lit. Cl.*]

March 7.
Dr Hutton's
theory of the
earth.

Phyf. Cl. Dr BLACK, in the absence of the Author, read the first part of Dr HUTTON's Theory of the Earth, which is published in this volume. [No. X. *Phyf. Cl.*]

Lit.

Lit. Cl. Dr GREGORY read a second part of his Essay on the general Notion of the Relation of Cause and Effect. [See *supra*, Nov. 15. 1784.]

1785.
March 21.
Dr Gregory on
cause and ef-
fect.

Phyf. Cl. Dr HUTTON read the second part of his Theory of the Earth, published in this volume. [No. X. *Phyf. Cl.*]

April 4.
Dr Hutton's
theory of the
earth.

AT a meeting of a Committee of the Royal Society, Mr ROBISON, General Secretary, presented to the Society from THOMAS HUTCHINS, Esq; his paper on the Congelation of Mercury, and from Dr HUTTON of Woolwich, his Logarithmic Tables.

May 27.
Donations.

Lit. Cl. The Reverend Dr MACFARLAN read a Discourse on the Advantages of Manufactures, Commerce and great Towns, to the Population and Prosperity of a Country. The Author having published this Discourse, it becomes unnecessary here to give any account of its contents.

June 20.
Dr Macfarlan
on manufac-
tures, &c.

A GENERAL meeting of the Royal Society was held for the election of the Office-bearers for the ensuing year. Those of the preceding year were unanimously continued in office.

June 27.
General meet-
ing.

Phyf. Cl. Dr WALKER read an Essay on the Flowers of Muscous Plants. He did not incline that any account should be given of the Essay in this volume.

July 4.
Dr Walker on
muscous plants.

AT a meeting of the Council of the Royal Society, Mr Commissioner SMITH informed the members, that he had received a letter from the Count de WINDISCHGRATZ, dated Bruffells, May 8. 1785, on the subject of a problem proposed by that nobleman to the learned men of all nations, which has for its object, the diminution of the number of law-suits by some required method, which, at the same time, shall impose no new restraints

July 9.
Count de Win-
dischgratz's
problem.

restraints on natural liberty. The problem, as announced in a printed *programma*, which accompanied the Count's letter to Mr SMITH, is as follows:

“ PRO omni possibili instrumentorum specie, quibus quis se
 “ obstringere, suumve dominium in alterum, quibuscunque
 “ ex motivis, et quibuscunque sub conditionibus transferre
 “ potest, formulas tales invenire, quæ omnibus casibus indivi-
 “ duis convenient, atque in quovis casu singulis duntaxat termi-
 “ nis, iisque pervulgatis expleri opus habeant, qui termini,
 “ æque ac ipsæ formularum expressiones ejusmodi sint, ut quem-
 “ admodum in mathesi, nullum dubium, nullum litigium lo-
 “ cum, habeat.”

A PRIZE of a thousand ducats is offered to any person who shall furnish a complete solution of this problem. Should there be no complete solution, a prize of five hundred ducats is offered to the author of that scheme, which shall be judged to approach the nearest to a solution. The Count proposes, in the printed *programma*, that all writings which shall be offered in the competition for these prizes, shall be judged of by three of the most distinguished Literary Academies in Europe. In his letter to Mr SMITH, he informs him, that the three learned bodies which he has chosen for that purpose are: The Royal Academy of Sciences at Paris, the Royal Society of Edinburgh, and one of the Academies of Germany or Switzerland, which he shall afterwards name. As a recompence for the trouble they may be put to in this decision, he offers the sum of 50 *louis d'or* to each of these learned bodies, to be assigned by them as a prize for the solution of any question which they shall propose. Count de WINDISCHGRATZ intimates, that the Academy of Sciences at Paris has accepted of the office required of them; and he desires that Mr SMITH will communicate his request to the Royal Society of Edinburgh, and inform him whether that body is willing to undertake the office of deciding

ding in the competition along with the Academy of Sciences, and the other Academy to be yet named.

1785.

Mr SMITH signified to the meeting, that although he entertained great doubt whether the problem of the Count de WINDISCHGRATZ admitted of any complete and rational solution, yet the views of the proposer being so highly laudable, and the object itself of that nature, that even an approximation to its attainment would be of importance to mankind; he was therefore of opinion, that the Society ought to agree to the request that was made to them. He added, that it was his intention to communicate his sentiments on the subject to the Count, by a letter, which he would lay before the Council at a subsequent meeting.—The Council were of opinion, That the Society should acquiesce in the Count de WINDISCHGRATZ's proposal, but should decline to accept of the recompence offered. The farther consideration, however, of the affair was postponed, till Mr SMITH should communicate to the Council the draught of his intended letter to the Count, on the subject of his problem.

Phyf. Cl. Dr GREGORY read a paper communicated by Dr HOPE, giving an account of a remarkable case, attended with anomalous symptoms, and terminating fatally; in which, on dissection, the disease appeared to have proceeded from a large gall-stone sticking in the neck of the gall-bladder.

Aug. 1.
Case communicated by Dr Hope.

Lit. Cl. Dr GREGORY read a continuation of his Essay on Cause and Effect. [See *supra*, Nov. 15. 1784.]

Nov. 21.
Dr Gregory on cause and effect.

Phyf. Cl. Mr WILLIAM SMELLIE read an Essay on Instinct. As this Essay makes a part of a larger work, which the author is preparing to lay before the Public, he did not wish it should appear at full length among the Dissertations printed in this volume.

Dec. 5.
Mr Smellie on Instinct.

lume. The following abstract, however, is given of its principal contents.

MANY theories have been invented with a view to explain the instinctive actions of animals, but none of them have received the general approbation of Philosophers. This want of success may be referred to different causes; to want of attention to the general oeconomy and manners of animals; to mistaken notions concerning the dignity of human nature; and, above all, to the uniform endeavour of Philosophers to distinguish instinctive from rational motives. Mr SMELLIE endeavours to shew that no such distinction exists, and that the reasoning faculty itself is a necessary result of instinct.

HE observes, that the proper method of investigating subjects of this kind, is to collect and arrange the facts which have been discovered, and to consider whether these lead to any general conclusions. According to this method, he exhibits examples, *First*, of pure instincts: *Secondly*, of such instincts as can accommodate themselves to particular circumstances and situations: *Thirdly*, of such as are improveable by experience or observation: And, *lastly*, he draws some conclusions.

By pure instincts are meant such as, independently of all instruction or experience, instantaneously produce certain actions, when particular objects are presented to animals, or when they are influenced by peculiar feelings. Such are, in the human species, the instinct of sucking, which is exerted by the infant immediately after birth, the voiding of fæces, the retraction of the muscles upon the application of any painful stimulus. The love of light is exhibited by infants, even so early as the third day after birth. The passion of fear is discoverable in a child at the age of two months.

AMONG the inferior animals, there are numberless pure instincts. Caterpillars shaken off a tree in every direction, turn immediately to the trunk, and climb up. Young birds open their mouths on hearing any noise, as well as that of their mother's

ther's voice. Every species of insect deposits its eggs in the situation most proper for hatching and affording nourishment to its future progeny. Some species of animals look not to future wants ; others, as the bee and the beaver, are endowed with an instinct which has the appearance of foresight. They construct magazines, and fill them with provisions. Bees display various remarkable instincts. They attend and feed the female or queen. When deprived of her, all their labours cease till a new one is obtained. They construct cells of three different dimensions ; for working bees, for drones and for females ; and the queen in depositing her eggs, puts each species into its appropriated cells. They destroy all the females but one, lest the hive should be overstocked. The different instincts of the common bee, of the wood-piercing bee, and of that species which builds cylindrical nests, with rose-leaves, are very remarkable.

EQUALLY singular are the instincts of wasps, and ichneumon flies, which though they feed not themselves upon worms, lay up stores of these animals for the nourishment of their young.

BIRDS build their nests of the same materials, and in the same form and situation, though they inhabit very different climates. They turn and shift their eggs, that they may be equally heated. Geese and ducks cover up their eggs till they return to the nest. The swallow solicits her young to void their excrement over the nest, and assists them in the operation. The spiders, and many insects of the beetle-kind, when put in terror, counterfeit death. This is not, as has been supposed, a convulsion or stupor, but an artifice ; for when the object of terror is removed, they recover immediately.

Of instincts which can accommodate themselves to peculiar circumstances and situations, many instances may be given from the human species ; but these being improveable, fall more properly under the third class.

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THOSE

THOSE animals are most perfect, whose sphere of knowledge extends to the greatest number of objects. When interrupted in their operations, they know how to resume their labours, and to accomplish their purposes by different means. Some animals have no other power but that of contracting or extending their bodies. But the falcon, the dog, and the fox, pursue their prey with intelligence and address.

IN Senegal, the ostrich sits upon her eggs only during the night, leaving them in the day to the heat of the sun. At the Cape of Good Hope, where the heat is not so great, she sits upon them day and night. Rabbits, when domesticated, are not inclined to burrow. Bees augment the depth of their cells, and increase their number, as occasion requires. A wasp carrying out a dead companion from the nest, if he finds it too heavy, cuts off the head, and carries out the load in two portions. In countries infested with monkeys, birds, which in other countries build in bushes or clefts of trees, suspend their nests at the end of slender twigs. The nymphæ of water-moths, which cover themselves with cases of straw, gravel, or shells, contrive to make their cases nearly in equilibrium with the water: When too heavy, they add a bit of wood or straw; when too light, a bit of gravel. A cat, when shut into a closet, has been known to open the latch with its paws.

THE third class of instincts comprehends all those that are improveable by experience and observation.

THE superiority of man over the other animals, seems to depend chiefly on the great number of instincts with which he is endowed. Traces of every instinct which he possesses are discoverable in the brute-creation, but no particular species enjoys the whole. On the contrary, most animals are limited to a small number. This appears to be the reason why the instincts of brutes are stronger, and more steady in their operation than those of man, and their actions more uniform.

Most

MOST human instincts receive improvement from experience and observation, and are capable of a thousand modifications. One instinct counteracts and modifies another, and often extinguishes the original motive to action. The instinct of fear is often counteracted by ambition and by resentment: The instinct of anger, by fear, by shame, by contempt, by compassion. Of modified, compounded, and extended instincts, there are many examples. Devotion is an extension of the instinct of love, to the first Cause or Author of the universe. Superstition is the instinct of fear extended to imaginary objects of terror. Hope is the instinct of love directed to future good. Avarice is the instinct of love directed to an improper object. Fear is likewise an ingredient of this attachment. Envy is compounded of love, avarice, ambition, and fear. Sympathy is the instinct of fear transferred to another person, and reflected back upon ourselves. In this manner all the modified, compounded or extended passions of the human mind, may be traced back to their original instincts.

THE instincts of brutes are likewise improved by observation and experience. Of such improvement, the dog, the elephant, the horse, the camel, afford numerous and strong instances.

FROM these and other examples, given of the different classes of instincts, Mr SMELLIE argues, that instinct is an original quality of mind, which, in man, as well as in other animals, may be improved, modified, and extended, by experience.

SENSATION implies a sentient principle or mind. Whatever feels, therefore, is mind. Of course, the lowest species of animals is endowed with mind. But the minds of animals have very different powers; and these powers are expressed by peculiar actions. The structure of their bodies is uniformly adapted to the powers of their minds; and no mature animal attempts actions which nature has not enabled it to perform: The instincts, however, of animals, appear often previously to the expansion of those instruments which nature intended they

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should

should employ. This view of instinct is simple: It removes every objection to the existence of mind in brutes, and unfolds all their actions by referring them to motives perfectly similar to those by which man is actuated. There is perhaps a greater difference between the mental powers of some animals, than between those of man and the most sagacious brutes. Instincts may be considered as so many internal senses, of which some animals have a greater, and others a smaller number. These senses, in different species, are likewise more or less ductile; and the animals possessing them are, of course, more or less susceptible of improving, and of acquiring knowledge.

THE notion that animals are machines, is therefore too absurd to merit refutation. Though not endowed with mental powers equal to those of man, they possess, in some degree, every faculty of the human mind. Sensation, memory, imagination, the principle of imitation, curiosity, cunning, ingenuity, devotion, or respect for superiors, gratitude, are all discoverable in the brute-creation. Every species too has a language, either of sounds or gestures, sufficient for the individuals to communicate their wants to each other; and some animals understand in part the language of man. The language of infants is nearly on a par with that of brutes. Brutes, without some portion of reason, could never make a proper use of their senses. But many animals are capable of balancing motives, which is a pretty high degree of reason. Young animals examine all objects they meet with, and in this investigation they employ all their organs. The first periods of their life are dedicated to study. When they run about and make frolicsome gambols, it is nature sporting with them for their instruction. Thus they gradually improve their faculties, and acquire an intimate knowledge of the objects that surround them. Men who, from peculiar circumstances, have been prevented from mingling with companions, and engaging in the different amusements and exercises of youth, are always awkward in their movements,

movements, cannot use their organs with ease or dexterity, and often continue, during life, ignorant of the most common objects.

1785.

AT a meeting of the Council of the Royal Society, the subject of the Count de WINDISCHGRATZ's Problem was resumed, and Mr Commissioner SMITH read to the Meeting the draught of a letter written by him to the Count, stating objections to the possibility of a complete solution of his problem, but intimating, at the same time, that the Royal Society of Edinburgh had agreed to co-operate with the other two Academies, in deciding on the merit of all Essays or Dissertations which should appear in the competition for the prizes proposed, though they declined to accept of the recompence offered in the Count's letter. The Council approved of Mr SMITH's letter, a copy of which they requested of the Author, in order to be preserved among their papers, as he did not incline that it should be published in the Transactions of the Society.

Dec. 13.
Count de Windischgratz's
problem.

APPEN-

A P P E N D I X.

MEMBERS DECEASED.

SINCE the institution of the Royal Society of Edinburgh, the following Members have died, *viz.*

William Lotbian, D. D. *senior* Minister of Canongate. December 17. 1783.

Sir George Clerk-Maxwell, Baronet, of Pennycuik. January 29. 1784.

Matthew Stewart, D. D. Emeritus Professor of Mathematics in the University of Edinburgh. January 23. 1785.

Andrew Crosbie, Esq; Vice-Dean of the Faculty of Advocates. February 25. 1785.

Robert Bruce, Esq; of Kennet, one of the Senators of the College of Justice. April 8. 1785.

Sir Alexander Dick, Baronet, of Prestonfield. November 10. 1785.

Alexander Wilson, M. D. Professor of Practical Astronomy in the University of Glasgow. October 16. 1786.

John Hope, M. D. King's Botanist in Scotland, and Professor of Medicine and Botany in the University of Edinburgh. November 11. 1786.

Robert Hamilton, D. D. Emeritus Professor of Divinity in the University of Edinburgh. April 2. 1787.

Sir James Hunter-Blair, Baronet, of Dunskey. July 1. 1787.

William Irvine, M. D. Lecturer on Chemistry in the University of Glasgow. July 9. 1787.

THE following BIOGRAPHICAL ACCOUNTS of the three first of these have been read at different meetings of the Classes.

I. ACCOUNT

I. ACCOUNT of WILLIAM LOTHIAN, D. D.

[Read by Mr DALZEL, March 15. 1784.]

THE custom adopted by several learned Societies or Academies abroad, which requires, that a professed panegyric on every one of the Members, after his death, should first be read before the Academy, and then printed in the history of their transactions, has not met with a general approbation, either in England or in this country. For although characters have frequently appeared in the republic of Letters, whose shining talents have, with sufficient propriety, employed the power of eloquence in their praise, every Member of an Academy cannot be deemed the proper subject of a laboured encomium. The British character, naturally shy and reserved, is apt to look with an eye of suspicion, upon any discourse that comes decorated with the pompous title of *Eloge*.

BUT though to write a professed panegyric on every deceased Member of our Society might, with reason, be thought ostentatious and improper; yet such is the merit and justly acquired literary fame of some of our number, that, to permit them to sink into the grave, without any public testimony of our regard, would argue a culpable degree of insensibility and reserve. There are names in our catalogue, whose praise will be publicly celebrated, and whose fame will descend to posterity, in spite of the silence which we might think proper to observe; and as they must stand forward in the Biographical Annals of Great Britain, where can an authentic memorial of them be so properly preserved as in the Registers of this Society?

IT

It seems proper also, that, at the death, even of every one of the Members, a short notice of him should be inserted in our Records: Mention ought to be made there of his birth and death, of the remarkable incidents of his life, and the claim he had to be inrolled among the Members of the Royal Society of Edinburgh; such a short and simple account having been previously read at a meeting of the Class to which he more particularly belonged.

BUT whoever has distinguished himself in a superior degree in the republic of Letters seems to have a claim to higher and more public honours. Nor could the most fastidious reserve be offended, if the memory of such a character were celebrated at an assembly of the whole Society.

THESE observations have been suggested by the recent loss of a worthy Member of our Literary Department. And as the omission of this first opportunity of introducing a practice, which seems so laudable, might be ascribed to negligence, or to an imperfect discharge of that trust with which the Society has honoured its Secretaries, I flatter myself the Meeting will hear, with indulgence, the following short and simple account of the person to whom I have alluded.

Account of
Dr Lothian.

WILLIAM LOTHIAN, D. D. *senior* Minister of Canongate, and Member of this Society, was born in the city of Edinburgh on the 5th of November 1740. Before he was six years old, he lost his father Mr GEORGE LOTHIAN, a respectable Surgeon; and his mother also having died when he was an infant, the charge of his education devolved on other relations.

HE had his academical education in the University of Edinburgh; and both during the usual course of Literature and Philosophy, and during his application to the study of Theology, he was distinguished for diligence and promising talents.

THE

THE students in that University have long been accustomed to form themselves into Societies, in which they canvass various subjects in Literature and Science, with such ardour and liberality of sentiment, as tend greatly to their improvement, both in knowledge and in public speaking. Into several of these Mr LOTHIAN was admitted, particularly into one which was well known, at that time, by the name of the *Belles-Lettres* Society; and many of the Members, who at present make a distinguished figure in public life, recollect, that he held an eminent place in their estimation.

Mr LOTHIAN was licensed to preach the Gospel in October 1762, and ordained Minister of Canongate in August 1764. As a Preacher, his method of instruction was simple and perspicuous, his sentiments rational and manly, and his manner unaffected and persuasive.

FOR many years before his death, he was afflicted with an alarming and painful disease; yet he exerted the activity of his mind and the remaining vigour of his constitution with such effect as enabled him to perform all his clerical functions, not only with propriety, but with apparent ease. He even found leisure to write the *History of the United Provinces of the Netherlands*, a part of which work he published in 1780, after having rendered it as perfect as the distressed habit of his constitution would permit. Previous to the appearance of this publication, the University of Edinburgh had conferred on him the degree of Doctor in Divinity.

IN his last illness, which was of long duration, and attended with most excruciating pain, his patience and fortitude supported his spirit in an extraordinary degree. He expired on the 17th of December 1783, having only completed the 43d year of his age.

HE was married, in the year 1776, to his cousin Mrs ELIZABETH LOTHIAN, who survives him, by whom he has left four sons and one daughter.

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As a member of the Church of Scotland, Dr LOTHIAN followed, with firmness, that course of conduct which seemed to him to be the most proper. And the appearances which he made in the Ecclesiastical Courts exhibited such marks of sound understanding, and such firmness of mind, as procured him great respect. Indeed, his contemporaries and younger brethren, among whom his acquaintance was very extensive, always reposed the highest confidence in his judgment, his honour and his integrity, and spoke in the strongest terms of the sincerity and warmth of his friendship.

WHEN this Society was honoured with a Royal Charter of Incorporation, Dr LOTHIAN was naturally thought of as a proper person to be inrolled among the number of its Members. But an early death has deprived us of the advantage of his labours.

BESIDES the above mentioned History, he published two Sermons, which are to be found in the second volume of a Collection, entitled, *The Scotch Preacher*, printed at Edinburgh in the year 1776.

II. ACCOUNT

II. ACCOUNT of Sir GEORGE CLERK-MAXWELL, Baronet.

[Read by Mr JOHN CLERK, junior, July 5. 1784.]

SIR GEORGE CLERK-MAXWELL of Pennycuik, Baronet, one of the Presidents of the Physical Class of this Society, was born at Edinburgh on the last day of October 1715. He was the fourth son of Sir JOHN CLERK of Pennycuik, one of the Barons of Exchequer in Scotland: His mother was a daughter of Sir JAMES INGLIS of Cramond.

HIS more early studies were carried on at the University of Edinburgh, under the eye of his father, who was himself a man of letters, and from whom he appears very early to have caught a strong taste for Natural History, Antiquities and the Theory of Commerce, particularly in so far as these branches of knowledge related to his own country. He afterwards went to Leyden, where he finished his studies under the immediate inspection of the celebrated BOERHAAVE, who had been the friend of his father; and, before his return home, he visited several parts of France and Germany.

AFTER settling in his native country, his turn of mind led him to study, with great diligence, the commercial interests of Scotland, and to be zealous and active in promoting them. He applied himself to the introduction and encouragement of various home-manufactures. In particular, he established, at a considerable expence to himself, the Linen Manufactory at Dumfries. He likewise set on foot many different projects for working lead and copper mines. In these laudable undertakings, the public advantage outweighed with him every other

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consideration;

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consideration; for his schemes were prosecuted frequently to the detriment of his private fortune.

IN 1755, he addressed *two Letters* to the Trustees for Fisheries, Manufactures and Improvements in Scotland, containing Observations on the common mode of treating Wool in this country, and suggesting a more judicious scheme of management. These were published, by direction of that Board, in 1756: And the method there recommended having been universally followed in practice, has been of real advantage to the public, by improving the quality of Scottish wool. He likewise, in 1761, wrote a paper on the Advantages of Shallow Plowing, which was read to the *Philosophical Society*, and is published in the third volume of their *Essays*.

IN 1741, Mr CLERK was appointed Lord Treasurer's Remembrancer in Exchequer; and, when the forfeited estates were put under the management of Commissioners in 1752, he was fixed on as a proper person to fill a place at their Board. In 1760, he was named one of the Trustees for Fisheries, Manufactures and Improvements: And in 1763, Commissioner of the Customs in Scotland.

His conduct in the discharge of the public trusts thus committed to him, was such as gained him the esteem and confidence of his colleagues. The two Boards of Trustees, in particular, often committed affairs of importance to his sole management; and he never failed to acquit himself to their entire satisfaction. Nor was his ability in their business more remarkable than his delicacy: For so scrupulous was he, that though he had justly acquired considerable influence at those Boards, he was never suspected of having once employed it in improper endeavours to serve his personal friends. In the course of his duty as a Commissioner of the Customs, he faithfully improved every opportunity of doing service to the Revenue.

ONE instance, among many, deserves particular notice, both as being a proof of the confidence reposed in him by the Board of Customs,

Customs, and as a remarkable public event, in which he was, though not ostensibly, one of the chief actors. For many years before 1764, the Isle of Man had been a source of great hurt to the Revenue, by being under the sovereignty of the family of ARTHOL; as it was exempted from duties, and consequently a receptacle for all the smugglers who frequented the west coast of Scotland. In 1764, Mr GRENVILLE, who was then Minister, turned his thoughts towards the means of correcting the abuses occasioned by the situation of the island, and applied to the Board of Customs for such information as was necessary towards forming a plan for that purpose. Mr CLERK was appointed by the Board to make a survey of the south-west coast, where the smugglers from the Isle of Man landed their goods. He executed the commission with great accuracy, and was soon after sent for by the Board of Treasury to make his report. He advised, that the sovereignty of the island should be purchased, and the same laws extended to it by which the rest of the British dominions were regulated, as the most effectual means of suppressing the illicit trade. Mr GRENVILLE, from motives of frugality, was at first extremely averse to a purchase of the sovereignty. As the public purse was then extremely low, and the object of the purchase of so great a value, he preferred a plan, which, together with some other regulations, was to increase the number of cruisers on the station. He had even gone so far as to form it into a bill, which he intended to have laid before Parliament, but was at last prevailed upon to give it up, after a perseverance of several months in the intention; during which time, Mr CLERK, in many conversations with him on the subject, laboured to convince him, that, without being adequate to its end, it would have loaded the public with a much greater expence than the sum necessary to purchase the sovereignty. At last, Mr CLERK's plan was followed, in almost every essential particular, by Administration, and it has been attended with the most beneficial consequences. The smuggling

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smuggling trade, though it still subsists, is now confined to those who are possessed of extensive capitals; whereas, before this act of Parliament, every farmer's servant who could purchase half a cask of spirits, was engaged for his share. The consequence is, that the whole inhabitants on the south-west coast, who had followed scarcely any other employment than this pernicious traffic, to the entire neglect of their husbandry and manufactures, now earn their subsistence by a more honest application of their industry. The face of the country, which formerly never could raise a sufficient quantity of grain to support its own inhabitants, is totally changed, and every year it affords a plentiful supply to the neighbouring counties.

MR CLERK was well acquainted with every branch of Natural History. To Mineralogy he had paid particular attention, from its immediate connection with his mining operations. His knowledge of Geography was so full and accurate, that he could describe, from memory, almost any city or remarkable place in the known world.

HE was likewise a skilful engineer and draughtsman, as appears from various roads, bridges, and other public works, in this country, executed under his direction, or on plans which he delineated. Nor were his talents in designing confined to this more mechanical species of drawing. He could seize and delineate, with uncommon spirit, every ludicrous expression of character; and his drawings in this line are in great request with the curious. His mind had likewise a bent to the army; which, however, was never gratified by action, excepting for a few months during the rebellion in 1745. At that time, he joined a military association of gentlemen, named *the Yorkshire Hunters*, who attended the royal army; and he was, on different occasions, employed by the Duke of CUMBERLAND, (who knew him well) and, in particular, to conduct the forces to the proper ground for opening the siege of Carlisle.

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Mr CLERK had an excellent taste for the fine arts, and was solicitous to encourage them. As one instance of this, he had the principal concern in establishing and procuring an endowment for the drawing-school in the University of Edinburgh, where twenty pupils are instructed *gratis* in the art of designing. These are selected from among such young people, of either sex, as give signs of genius, who are destined to apply to those professions in which a skill in that art is requisite. This institution has contributed more than any other circumstance, to the great improvement of ornamental manufactory, which this country has made during the last twenty years. And whoever recollects the old patterns of carpet, damask, gauze, and other manufactures of that sort, and compares them with those of the present day, must allow the superior elegance of design now exhibited in those productions, and which may reasonably be ascribed, in a great measure, to the happy effects produced by the institution we have mentioned.

HE married, at a very early period of life, his cousin-german DOROTHY CLERK-MAXWELL, heiress of Middlebie in Dumfries-shire, by whom he had six sons and seven daughters, of whom only two sons and two daughters survived him. He succeeded to his elder brother Sir JAMES CLERK, in the title of Knight Baronet, in the year 1783.

DURING the latter years of his life, his constitution and spirits suffered many severe shocks from family misfortunes. He lost, within a short time, three sons, a daughter, and a grandson, all of whom had arrived at years of maturity, and promised to be the comfort of his old age. Of these, his third son GEORGE, who had been some years at the Bar, died in 1776. WILLIAM, his fifth, a Lieutenant in the 1st regiment of foot; ROBERT, his sixth, a Lieutenant in the 56th, and GEORGE CRAIGIE younger of Glendoick, his grandson, a Captain in the 40th regiment, all perished in the service of their country, within the period of a few months. The last mentioned of these, in the
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end of 1781, was killed at the storm of New London, just as he had mounted the rampart; ROBERT died at Gibraltar, about the same time; and WILLIAM was killed at the siege of St Christopher's, in the beginning of 1782. These four young gentlemen were all of the most promising expectations; and it is rarely that one family sustains such accumulated misfortunes. Sir GEORGE's daughter died of grief for the loss of her brothers and nephew. In addition to these calamities, the most acute bodily pains gradually wasted his constitution. He bore all his distresses with unshaken fortitude to the last, and attended to the duties of the public Boards of which he was a Member, with his wonted assiduity and perseverance, till within a few days of his death, which happened on the 29th of January 1784. It will be fortunate for his country, if many are left behind him, as sincerely attached to its welfare, and as active and disinterested in promoting it.

III. ACCOUNT

III. ACCOUNT of *MATTHEW STEWART*, D. D.

[Read by Mr JOHN PLATFAIR, April 3. 1786.]

THE Reverend Dr *MATTHEW STEWART*, late Professor of Mathematics in the University of Edinburgh, was the son of the Reverend Mr DUGALD STEWART, Minister of Rothsay in the Isle of Bute, and was born at that place in the year 1717. After having finished his course at the grammar-school, being intended by his father for the Church, he was sent to the University of Glasgow, and was entered there as a student in 1734. His academical studies were prosecuted with diligence and success; and he was so happy as to be particularly distinguished by the friendship of Dr HUTCHESON and Dr SIMSON. With the latter, indeed, he soon became very intimately connected; for though it is said, that his predilection for the Mathematics did not instantly appear on his application to the study of that science, yet the particular direction of his talents was probably observed by his master before it was perceived by himself. Accordingly, after being the pupil of Dr SIMSON, he became his friend; and during all the time that he remained at the University of Glasgow, pursuing the studies of Philosophy and Theology, he lived in the closest intimacy with that excellent Mathematician, and was instructed by him in, what might not improperly be called, the *arcana* of the ancient Geometry. That science was yet involved in some degree of mystery; for though the extent of its discoveries was nearly ascertained, its analysis, or method of investigation, was but imperfectly understood, and seemed inadequate to the discoveries

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coveries which had been made by it. The learning and genius of VIVIANI, FERMAT, HALLEY, and of other excellent Mathematicians, had already been employed in removing this difficulty; but their efforts had not been attended with complete success. Dr SIMSON was now engaged in perfecting what they had begun, and in resisting the encroachments, which he conceived the modern analysis to be making upon the ancient. With this view, he had already published a treatise of Conic Sections, and was now preparing a restoration of the *Loci Plani* of APOLLONIUS, in which that work was to resume its original elegance and simplicity. To these, and other studies of the same kind, he constantly directed the attention of his young friend, while he was delighted, and astonished at the rapidity of his progress.

Mr STEWART's views made it necessary for him to attend the lectures in the University of Edinburgh in 1741; and that his mathematical studies might suffer no interruption, he was introduced by Dr SIMSON to Mr MACLAURIN, who was then teaching, with so much success, both the Geometry and the Philosophy of NEWTON. Mr STEWART attended his lectures, and made that proficiency which was to be expected from the abilities of such a pupil, directed by those of so great a master. But the modern analysis, even when thus powerfully recommended, was not able to withdraw his attention from the ancient Geometry. He kept up a regular correspondence with Dr SIMSON, giving him an account of his progress, and of his discoveries in Geometry, which were now both numerous and important, and receiving in return many curious communications with respect to the *Loci Plani*, and the Porisms of EUCLID. These last formed the most intricate and paradoxical subject in the history of the ancient Mathematics. Every thing concerning them, but the name, had perished. PAPPUS ALEXANDRINUS has made mention of three books of Porisms written by EUCLID, and has given an account of what they contained; but this

this account has suffered so much from the injuries of time, that the sense of one proposition only is complete. There was no diagram to direct the Geometer in his researches, nor any general notion of the subject, or of the form of the propositions, to serve as a rule for his conjectures. The task, therefore, of restoring these ancient books, which Dr SIMSON now imposed on himself, exceeded infinitely the ordinary labours of the Critic or the Antiquary; and it was only by uniting the learning and diligence of these two characters, with the skill of a profound Geometer, that he was at last successful in this difficult undertaking. He had begun it as early as the year 1727, but seems to have communicated the whole progress of his discoveries to Mr STEWART alone.

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WHILE the second invention of Porisms, to which more genius was perhaps required than to the first discovery of them, employed Dr SIMSON, Mr STEWART pursued the same subject in a different, and new direction. In doing so, he was led to the discovery of those curious and interesting propositions, which were published, under the title of *General Theorems*, in 1746. They were given without the demonstrations; but did not fail to place their Discoverer at once among the Geometers of the first rank. They are, for the most part, Porisms, though Mr STEWART, careful not to anticipate the discoveries of his friend, gave them no other name than that of Theorems. They are among the most beautiful, as well as most general propositions known in the whole compass of Geometry, and are perhaps only equalled by the remarkable *Locus* to the circle in the second book of APOLLONIUS, or by the celebrated theorem of Mr COTES. The first demonstration of any considerable number of them, is that which was lately communicated to this Society*, though I believe there are few Mathematicians, into whose hands they have fallen, whose skill they have not often exercised. The unity which prevails among them is a proof, that a single, though ex-

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* By the Reverend Dr SMALL.

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tensive view, guided Mr STEWART in the discovery of them all. It seems probable, that, while he aimed at extending Geometry beyond the limits it had reached with the ancients, he had begun to consider the *Locus ad quatuor rectas*, beyond which their analysis had not reached. With this view, he, no doubt, thought of extending the hypotheses of that problem to their utmost generality; that is, to any number of perpendiculars drawn to an equal number of lines, and to any power whatever of these perpendiculars. In doing this, he could not fail to meet with many curious porisms; for a porism is nothing else than that particular case, when the data of a problem are so related to one another, as to render it indefinite, or capable of innumerable solutions. These cases, which rarely occur, except in the construction of very general and complicated problems, must always interest a Geometer, because they trace out the divisions of his subject, and are usually distinguished by an elegance and simplicity peculiar to themselves. Such, accordingly, were the propositions which Mr STEWART now communicated to the world. He suppressed his investigations, however, which were geometrical, and which, if given with all the precision required by the forms of the ancient Geometry, would probably have occupied several volumes.

THE history of these geometrical discoveries has led us to neglect the order of time. For Mr STEWART, while engaged in them, had entered into the Church, and, through the patronage of the Earl of BUTE and the Duke of ARGYLE, had obtained the living of Roseneath. It was in that retired and romantic situation, that he discovered the greater part of the propositions that have just been mentioned. There, also, he used to receive the visits of his friend Mr MELVIL, whose ingenious observations in the *Physical and Literary Essays*, give us cause to regret that he was so early taken from the world of science*.

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* Observations on Light and Colours, Phys. and Lit. Essays, vol. ii. art. 4.

IN the summer of 1746, the Mathematical Chair in the University of Edinburgh became vacant by the death of Mr MACLAURIN. The *General Theorems* had not yet appeared; Mr STEWART was known only to his friends; and the eyes of the public were naturally turned on Mr STIRLING, who then resided at Leadhills, and who was well known in the mathematical world. He, however, declined appearing as a candidate for the vacant chair; and several others were named, among whom was Mr STEWART. In the end of this year, the *General Theorems* were published, and gave to their Author a decided superiority above all the other candidates. He was accordingly elected Professor of Mathematics in the University of Edinburgh, in the beginning of September 1747.

THE duties of this office gave a turn somewhat different to his mathematical pursuits, and led him to think of the most simple and elegant means of explaining those difficult propositions, which were hitherto only accessible to men deeply versed in the modern analysis. In doing this, he was pursuing the object which, of all others, he most ardently wished to attain, viz. the application of Geometry to such problems as the algebraic calculus alone had been thought able to resolve. His solution of KEPLER's problem was the first specimen of this kind which he gave to the world; and it was impossible to have produced one more to the credit of the method he followed, or of the abilities with which he applied it. When the Astronomer, from whom that problem takes its name, discovered the elliptical motion of the planets, and their equable description of areas round the sun, he reduced the problem, of computing the place of a planet for a given time, to that of drawing a line through the focus of an ellipse, that should divide the area of the semi-ellipse in a given ratio. It was soon found, that this problem did not admit of an accurate solution; and that no more was to be expected, than an easy and exact approximation. In this, ever since the days of KEPLER, the Mathematicians

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ticians of the first name had been engaged, and the utmost resources of the integral calculus had been employed. But though many excellent solutions had been given, there was none of them at once direct in its method and simple in its principles. Mr STEWART was so happy as to attain both these objects. He founds his solution on a general property of curves, which, though very simple, had perhaps never been observed; and by a most ingenious application of that property, he shows how the approximation may be continued to any degree of accuracy, in a series of results which converge with prodigious rapidity. Whoever examines this solution will be astonished to find a problem brought down to the level of elementary Geometry, which had hitherto seemed to require the finding of fluents and the reversion of series; he will acknowledge the reasonableness of whatever confidence Mr STEWART may be hereafter found to place in those simple methods of investigation, which he could conduct with so much ingenuity and success; and will be convinced, that the solution of a problem, though the most elementary, may be the least obvious, and, though the easiest to be understood, may be the most difficult to be discovered.

THIS solution appeared in the second volume of the Essays of the Philosophical Society of Edinburgh, for the year 1756. In the first volume of the same Collection, there are some other propositions of Mr STEWART's, which are an extension of a curious theorem in the fourth book of PAPPUS. They have a relation to the subject of porisms, and one of them forms the 91st of Dr SIMSON's Restoration. They are besides very beautiful propositions, and are demonstrated with all the elegance and simplicity of the ancient analysis.

IT has been already mentioned, that Mr STEWART had formed the plan of introducing into the higher parts of mixed Mathematics the strict and simple form of ancient demonstration. The prosecution of this plan produced the *Traacts Physical and Mathematical*, which were published in 1761. In the first of these,

these, Mr STEWART lays down the doctrine of centripetal forces, in a series of propositions, demonstrated (if we admit the quadrature of curves) with the utmost rigour, and requiring no previous knowledge of the Mathematics, except the elements of plain Geometry, and of Conic Sections. The good order of these propositions, added to the clearness and simplicity of the demonstrations, renders this Tract the best elementary treatise of Physical Astronomy that is any where to be found.

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IN the three remaining Tracts, our Author had it in view to determine, by the same rigorous method, the effect of those forces which disturb the motions of a secondary planet. From this he proposed to deduce, not only a theory of the moon, but a determination of the sun's distance from the earth. The former is well known to be the most difficult subject to which Mathematics have been applied. Though begun by Sir ISAAC NEWTON, and explained, as to its principles, with singular success; yet, as to the full detail and particular explanation of each irregularity, it was left by that great Philosopher, less perfect than any other of his researches. Succeeding Mathematicians had been employed about the same subject; the problem of the *Three bodies* had been proposed in all its generality, and in as far as regards the motion of the moon, had been resolved by a direct and accurate approximation. But the intricacy and length of these calculations rendered them intelligible only to those, who were well versed in the higher parts of the Mathematics. This was what Dr STEWART proposed to remedy, by giving a theory of the moon that might depend, if possible, on Elementary Geometry alone, or which should, at least, be the simplest that the nature of things would allow. The Tracts were destined to serve as the basis of this investigation. We are not, however, to imagine, that Dr STEWART intended to proceed in the same direct manner that CLAIRAULT, and some other Geometers, had done. It is not probable, that he believed this to be with-

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in the power of pure Geometry. His design undoubtedly was, to pursue that method of approximation which Sir ISAAC NEWTON had begun, and which CALLENDRINI, MACHIN and WALMSLEY had greatly improved; and, by using the methods of Geometry, he hoped to reduce the problem to its ultimate simplicity. Such an undertaking was worthy of a great Geometer, and of a Philosopher, who considered that one of the chief obstructions to the advancement of knowledge, is the difficulty of simplifying that knowledge, which has already been acquired. We must regret, therefore, that the decline of Dr STEWART's health, which began soon after the publication of the Tracts, did not permit him to pursue this investigation.

THE other object of the Tracts was to determine the distance of the sun, from his effect in disturbing the motions of the moon. The approach of the transit of Venus, which was to happen in 1761, had turned the attention of Mathematicians to the solution of this curious problem. But when it was considered, of how delicate a nature the observations were from which that solution was to be deduced, and to how many accidents they were exposed, it was natural, that some attempt should be made to ascertain the dimensions of our system, by means less subject to disappointment. Such accordingly was the design of Dr STEWART; and his enquiries into the lunar irregularities had furnished him with the means of accomplishing it.

THE theory of the composition and resolution of forces enables us to determine what part of the solar force is employed in disturbing the motions of the moon; and, therefore, could we measure the instantaneous effect of that force, or the number of feet by which it accelerates or retards the moon's motion in a second, we should be able to determine how many feet the whole force of the sun would make a body, at the distance of the moon, or of the earth, descend in a second, and, consequently, how much the earth is, in every instant,

stant turned out of its rectilinear course. Thus, the curvature of the earth's orbit, or, which is the same thing, the radius of that orbit, that is, the distance of the sun from the earth, would be determined. But the fact is, that the instantaneous effects of the sun's disturbing force are too minute to be measured; and that it is only the effect of that force, continued for an entire revolution, or some considerable portion of a revolution, which Astronomers are able to observe.

THERE is yet a greater difficulty which embarrasses the solution of this problem. For, as it is only by the difference of the forces exerted by the sun on the earth and on the moon, that the motions of the latter are disturbed, the farther off the sun is supposed, the less will be the force by which he disturbs the moon's motions; yet that force will not diminish beyond a fixed limit, and a certain disturbance would obtain, even if the distance of the sun were infinite. Now the sun is actually placed at so great a distance, that all the disturbances, which he produces on the lunar motions are very near to this limit, and therefore a small mistake in estimating their quantity, or in reasoning about them, may give the distance of the sun infinite, or even impossible. But all this did not deter Dr STEWART from undertaking the solution of the problem, with no other assistance than that which Geometry could afford. Indeed, the idea of such a problem had first occurred to Mr MACHIN, who, in his book on the Laws of the Moon's Motion, has just mentioned it, and given the result of a rude calculation, (the method of which he does not explain) which assigns 8" for the parallax of the sun. He made use of the motion of the nodes, but Dr STEWART considered the motion of the apogee, or of the longer axis of the moon's orbit, as the irregularity best adapted to his purpose. It is well known, that the orbit of the moon is not immovable, but that, in consequence of the disturbing force of the sun, the longer axis of that orbit has an angular motion, by which it

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goes back about three degrees in every lunation, and completes an entire revolution in nine years nearly. This motion, though very remarkable and easily determined, has the same fault, in respect of the present problem, that was ascribed to the other irregularities of the moon; for a very small part of it only depends on the parallax of the sun; and of this Dr STEWART, as will afterwards appear, seems not to have been perfectly aware.

THE propositions, however, which defined the relation between the sun's distance and the mean motion of the apogee, were published among the Tracts in 1761. The transit of Venus happened in that same year: the Astronomers returned, who had viewed that curious phenomenon from the most distant stations; and no very satisfactory result was obtained from a comparison of their observations. Dr STEWART then resolved to apply the principles he had already laid down; and, in 1763, he published his essay on the sun's distance, where the computation being actually made, the parallax of the sun was found to be no more than 6". 9. and his distance, of consequence, almost 29875 semidiameters of the earth*.

A DETERMINATION of the sun's distance, that so far exceeded all former estimations of it, was received with surprise, and the reasoning on which it was founded was likely to be subjected to a severe examination. But, even among Astronomers, it was not every one who could judge in a matter of such difficult discussion. Accordingly, it was not till about five years after the publication of the *Sun's Distance*, that there appeared a pamphlet under the title of *Four Propositions*, intended to point out certain errors in Dr STEWART's investigation, which had given a result much greater than the truth. A dispute in Geometry was matter of wonder to many, and perhaps

* About 118,541,428 English miles.

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perhaps of satisfaction to some, who envied that science the certainty of its conclusions. On account of such, it must be observed, that there are problems so extremely difficult, that, in the solution of them, it is possible only to approximate to the truth; and that, as in Arithmetic, we neglect those small fractions, which, though of inconsiderable amount, would exceedingly embarrass our computations; so, in Geometry, it is sometimes necessary to reject those small quantities, which would add little to the accuracy, and much to the difficulty of the investigation. In both cases, however, the same thing may happen; though each quantity thrown out may be inconsiderable in itself, yet the amount of them altogether, and their effect on the last result, may be greater than is apprehended. This was just what had happened in the present case. The problem to be resolved is, in its nature, so complex, and involves the estimation of so many causes, that, to avoid inextricable difficulties, it is necessary to reject some quantities, as being small in comparison of the rest, and to reason as if they had no existence. Dr STEWART, too, it must be confessed, had an additional motive for wishing to simplify his investigation. This was, his resolution, to employ in it no other method than the Geometrical, which, however excellent in other respects, is inferior to Algebra, for the conducting of very complicated reasonings. The skill of this most profound and experienced Geometer, could not remedy that defect; and he was reduced to the necessity of rejecting quantities, which were considerable enough to have a great effect on the last result. An error was thereby introduced, which, had it not been for certain compensations, would have become immediately obvious, by giving the sun's distance near three times as great as that which has been mentioned.

THE Author of the pamphlet, referred to above, was the first who remarked the dangerous nature of these simplifications, and who attempted to estimate the error to which they had

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given rise. In this last, however, he has not completely succeeded; and that, too, by committing a mistake similar to that which he censured in Dr STEWART, and by rejecting quantities not less than some which he retained. He observed, however, what produced the compensation that has been taken notice of, *viz.* the immense variation of the sun's distance, which corresponds to a very small variation of the motion of the moon's apogee. It is doubtful, whether Dr STEWART was fully apprised of this circumstance; because the geometrical method, elegant and beautiful as it is, rarely presents a general view of the relations, which the magnitudes it treats of bear to one another; and many of these relations may, therefore, escape the most profound Geometer, which an Algebraist, of more ordinary abilities, would not have failed to discover.

THERE are other of this Author's strictures, which we cannot admit as just, but which we will not attempt here, either to enumerate or refute. Yet it were doing great injustice to his remarks not to acknowledge, that, besides being just in the points already mentioned, they are, every where, ingenious, and written with much modesty and good temper. The Author, who concealed his name, and permits it now, for the first time, to be publicly mentioned, was Mr DAWSON, a surgeon at Sudbury in Yorkshire; a man, as it should seem, who might have enjoyed more of the fame, had he been less satisfied with the possession of knowledge.

A SECOND attack was soon after this made on the *Sun's Distance*, by Mr LANDEN; but by no means with the same good temper which has been remarked in the former. He fancied to himself errors in Dr STEWART's investigation, which have no existence; he exaggerated those that were real, and seemed to triumph in the discovery of them with unbecoming exultation. If there are any subjects on which men may be expected to reason dispassionately, they are certainly the properties of
number

number and extension ; and whatever pretexts Moralists or Divines may have for abusing one another, Mathematicians can lay claim to no such indulgence. The asperity of Mr LANDEN's animadversions must not, therefore, pass uncensured, though it be united with sound reasoning and accurate discussion. The error into which Dr STEWART had fallen, though before taken notice of by Mr DAWSON, was first exactly determined in the work before us *. But Mr LANDEN, in the zeal of correction, brings many other charges against Dr STEWART, the greater part of which seem to have no good foundation. Such are his objections to the second part of the investigation, where Dr STEWART finds the relation between the disturbing force of the sun, and the motion of the apsides of the lunar orbit. For this part, instead of being liable to objection, is deserving of the greatest praise, since it resolves, by Geometry alone, a problem which had eluded the efforts of some of the ablest Mathematicians, even when they availed themselves of the utmost resources of the integral calculus. Sir ISAAC NEWTON, though he assumed the disturbing force very near the truth, computed the motion of the apsides from thence only at one half of what it amounts to in reality ; and so, had he been required, like Dr STEWART, to invert the problem, he would have committed an error, not merely of a few thousandth parts, as the latter is alleged to have done, but would have brought out a result double of the truth †. MACHIN and CALLENDRINI, when commenting on this part of the *Principia*, found a like inconsistency between their theory and observation. Three other celebrated Mathematicians, CLAIRAULT, D'ALEMBERT and EULER, separately experienced the same difficulties,

* It is but justice to remark, that Mr LANDEN had probably never seen Mr DAWSON's Propositions at the time his own were published, the whole impression of them, almost, having been burnt by a fire which consumed the warehouse where they were lodged.

† Prin. Math. lib. 3. prop. 3.

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difficulties, and were led into an error of the same magnitude. It is true, that, on resuming their computations, they found, that they had not carried their approximations to a sufficient length, which when they had, at last, accomplished, their results agreed exactly with observation. Mr WALMSLEY and Dr STEWART were, I think, the first Mathematicians, who, employing in the solution of this difficult problem, the one the algebraic calculus, and the other the geometrical method, were led immediately to the truth; a circumstance so much for the honour of both, that it ought, by no means, to be forgotten. It was the business of an impartial critic, while he examined our Author's reasonings, to have remarked, and to have weighed these considerations.

WE may add, that the accurate measurement of the sun's distance, and the complete theory of the moon's motions, with which science has been enriched, since the time to which we now refer, sufficiently vindicate the principle of Dr STEWART's investigation, and show how much reason he had to expect, that the former might be inferred from the latter with considerable exactness. M. MAYER, from one of the lunar irregularities, computes the sun's parallax to be $7''.8$, nearly a mean between the parallax already mentioned, and that which has been deduced from the transit of Venus in 1769*.

ON the whole, therefore, while it must be acknowledged, that Dr STEWART's determination of the sun's distance is, by no means, free from error, it may safely be asserted, that it contains a great deal which will always interest Geometers, and always be admired by them. Few errors in science are redeemed by the display of so much ingenuity, and what is more singular, of so much sound reasoning. The investigation is every where elegant, and will, probably, be long regarded as a specimen of the most arduous enquiry which has been attempted by mere Geometry; at the same time, the mistake into which the geometrical method has betrayed this great Mathematician, will

serve

* *Theoria Lunæ*, sect. 51.

serve as a proof that it is not equal to such difficult researches ; and that in those cases, especially, where approximation is to be used, it is necessary to sacrifice the rigour of the ancient demonstration for the accuracy of the modern analysis.

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THE *Sun's Distance* was the last work which Dr STEWART published ; and though he lived to see the animadversions made on it, that have been taken notice of above, he declined entering into any controversy. His disposition was far from polemical ; and he knew the value of that quiet, which a literary man should rarely suffer his antagonists to interrupt. He used to say, that the decision of the point in question was now before the public ; that, if his investigation was right, it would never be overturned, and that, if it was wrong, it ought not to be defended.

A FEW months before he published the Essay just mentioned, he gave to the world another work, entitled, *Propositiones Geometricæ More Veterum Demonstratæ*. This title, I have been told, was given it by Dr SIMSON, who rejoiced in the publication of a work so well calculated to promote the study of the ancient Geometry. It consists of a series of geometrical theorems, for the most part, new ; investigated, first, by an analysis, and afterwards synthetically demonstrated by the inversion of the same analysis. In the former, the proposition to be investigated is supposed true ; from thence consequences are deduced, and the reasoning is carried on till some consequence is drawn that is already known to be true. A necessary connection is thus traced between the proposition that was supposed true, and another that is certainly known to be so ; and, thus, an ingenious method is laid down for making the knowledge of any truth subservient to the discovery of its demonstration. This method made an important part in the analysis of the ancient Geometers ; but few examples of it have been preserved in their writings, and those in the *Propositiones Geometricæ*, are, on that account, the more valuable.

Dr

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Dr STEWART's constant use of the geometrical analysis had put him in possession of many valuable propositions, which did not enter into the plan of any of the works that have been enumerated. Of these, not a few have found a place in the writings of Dr SIMSON, where they will for ever remain, to mark the friendship of these two Mathematicians, and to evince the esteem which Dr SIMSON entertained for the abilities of his pupil. In the preface to his Conic Sections, in which he acknowledges, that all the theorems, distinguished by the letter α , were communications from Dr STEWART, he calls him, "egregiæ indolis et peritiæ virum;" and in that to his Porisms, after pointing out many propositions that had been suggested by PAPPUS, and a few that had been adopted from FERMAT, he adds, "Alia quædam adjecta sunt quorum præcipua mihi proposuit, et aliquorum constructionem dedit eximius Geometra MATTHÆUS STEWART, a quo materia hæc jam egregie est ex-culta, postea, ut spero, multum excolenda."

THERE is also a theorem of Dr STEWART's published in Dr SIMSON's edition of EUCLID's *Data*, which I take notice of, chiefly as it affords me an opportunity of paying a tribute to the memory of a man, whose high rank did not prevent him from cultivating a science, which it enabled him to patronize. In the note, where Dr SIMSON acknowledges that communication, he mentions another theorem, also published among the *Data*; "These propositions (says he) were communicated to me by two excellent Geometers, the first by the Earl STANHOPE, the second by Dr MATTHEW STEWART."

To this Nobleman, for whose abilities and worth Dr STEWART entertained the highest respect, he made a visit in the course of a tour through England, soon after the publication of the Essay on the Sun's Distance, and received from him very singular marks of attention. At a later period, when he lamented the loss of Dr SIMSON, he had the consolation

consolation to see a lasting monument raised to the fame of his friend, by the munificence of Lord STANHOPE, who, by the publication of Dr SIMSON's posthumous works, has obliged the world with a *restoration* of the most curious fragment of the Greek Geometry.

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SOON after the publication of the *Sun's Distance*, Dr STEWART's health began to decline, and the duties of his office became burdensome to him. In the year 1772, he retired to the country, where he afterwards spent the greater part of his life, and never resumed his labours in the University. He was, however, so fortunate as to have a son, to whom, though very young, he could commit the care of them with the greatest confidence. Mr DUGALD STEWART, having begun to give lectures for his father from the period above mentioned, was elected joint Professor with him in 1775, and gave an early specimen of those abilities, which have not been confined to a single science.

AFTER mathematical studies (on account of the bad state of health into which Dr STEWART was now falling) had ceased to be his business, they continued to be his amusement. The analogy between the circle and hyperbola had been an early object of his admiration. The extensive views which that analogy is continually opening; the alternate appearance and disappearance of resemblance in the midst of so much dissimilitude, make it an object that astonishes the experienced, as well as the young Geometer. To the consideration of this analogy, therefore, the mind of Dr STEWART very naturally returned, when disengaged from other speculations. His usual success still attended his investigations; and he has left, among his papers, some curious approximations to the areas, both of the circle and hyperbola. For some years toward the end of his life, his health scarcely allowed him to prosecute study even as an amusement. He died January 23. 1785, at the age of 68.

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THE

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THE habits of study, in a man of original genius, are objects of curiosity, and deserve to be remembered. Concerning those of Dr STEWART, his writings have made it unnecessary to remark, that, from his youth, he had been accustomed to the most intense, and continued application. In consequence of this application, added to the natural vigour of his mind, he retained the memory of his discoveries in a manner that will hardly be believed. He rarely wrote down any of his investigations, till it became necessary to do so for the purpose of publication. When he discovered any proposition, he would put down the enunciation with great accuracy, and, on the same piece of paper, would construct very neatly the figure to which it referred. To these he trusted for recalling to his mind, at any future period, the demonstration, or the analysis, however complicated it might be. Experience had taught him, that he might place this confidence in himself without any danger of disappointment; and for this singular power, he was probably more indebted to the activity of his invention, than the mere tenaciousness of his memory.

THOUGH he was extremely studious, he read few books, and verified the observation of M. D'ALEMBERT, that, of all the men of letters, Mathematicians read least of the writings of one another. His own investigations occupied him sufficiently; and, indeed, the world would have had reason to regret the misapplication of his talents, had he employed, in the mere acquisition of knowledge, that time which he could dedicate to works of invention.

It was his custom to spend the summer at a delightful retreat in Ayrshire, where, after the academical labours of the winter were ended, he found the leisure necessary for the prosecution of his researches. In his way thither, he frequently made a visit to Dr SIMSON at Glasgow, with whom he had lived from his youth in the most cordial and uninterrupted friendship.

ship. It was pleasing to observe, in these two profound Mathematicians, the most perfect esteem and affection for each other, and the most entire absence of jealousy, though no two men ever trode more nearly in the same path. The similitude of their pursuits, as it will ever do with men superior to envy, served only to endear them to one another. Their sentiments and views of the science they cultivated were nearly the same; they were both profound Geometers; they equally admired the ancient Mathematicians, and were equally versed in their methods of investigation; and they were both apprehensive, that the beauty of their favourite science would be forgotten for the less elegant methods of algebraic computation*. This innovation they endeavoured to oppose; the one, by reviving those books of the ancient Geometry which were lost; the other, by extending that Geometry to the most difficult enquiries of the moderns. Dr STEWART, in particular, had remarked the intricacies, in which many of the greatest of the modern Mathematicians had involved themselves in the application of the calculus, which a little attention to the ancient Geometry would certainly have enabled them to avoid. He had observed, too, the elegant synthetical demonstrations that, on many occasions, may be given of the most difficult propositions, investigated by the inverse method of fluxions. These circumstances had, perhaps, made a stronger impression than they ought, on a mind already filled with admiration of the ancient Geometry, and produced too unfavourable an opinion of the modern analysis. But, if it be confessed, that Dr STEWART rated, in any respect too high, the merit of the former of these sciences,

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this

* On the reverse of a miniature picture of Dr SIMSON, now in the possession of Mr Prof. STEWART, is an inscription, written by Dr MOOR, late Professor of Greek at Glasgow, an intimate friend of Dr SIMSON, and a great admirer of the ancient Geometry:

GEOMETRIAM, SUB TYRANNO BARBARO SAEVA SERVITUTE DIU SQUALENTEM, IN
LIBERTATEM ET DECUS ANTIQVUM VINDICAVIT VNVS.

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this may well be excused in the man whom it had conducted to the discovery of the *General Theorems*, to the *solution of KEPLER'S Problem*, and to an *accurate* determination of the *Sun's disturbing force*. His great modesty made him ascribe to the method he used, that success which he owed to his own abilities.

DONATIONS

DONATIONS presented to the ROYAL SOCIETY of Edinburgh.

[N. B. The numbers refer to the order in which the articles are deposited in the Museum of the University of Edinburgh.]

By his Grace the Duke of Buccleugh.

The Head, Horns and Bones of the BISON *Scoticus*, found in a peat-moss upon the Duke's estate in Roxburghshire. No. 1.—4.

By Dr Alexander Monro.

Thirty-eight coloured Drawings of Birds, of the southern hemisphere. No. 5.—42.

The Head and Horns of the *Arnee*, from Bengal. No. 43.

By the Honourable Lord Dunfinnan.

A painting in oil, of the Head and Horns of an Elk, found in a marl-pit in Forfarshire. No. 44.

By the Honourable Lord Hailes.

A large Mass of the Rock at Gibraltar, containing Bones. No. 45.

The Ear of a Whale, from Greenland. No. 46.

The Head of a Fish, petrified. No. 47.

The *Vertebrae* of three different species of animals, petrified. No. 48. 49. 50.

Glossopetra, belonging to two different species of Shark. No. 51. 52.

Two crustaceous animals petrified. No. 53. 54.

Three

List of Donations.

Three different species of *Echinus* petrified. No. 55. 56. 57.
 Four different species of *Nautilus* petrified. No. 58.—62.
 Six different species of turbinated Shells petrified. No. 63.—68.
 Ten species of turbinated Shells petrified. No. 69.—78.
 Three species of Shells. No. 79.—81.
 Four species of *Madrepore*. No. 82.—85.
 Red Coral from the Mediterranean. No. 86.
 Six species of *Gorgonia*. No. 87.—92.
SPONGIA Aculeata. LIN. No. 93.
OSTREA Folium. LIN. No. 94.
 Two Indian Arrows poisoned. No. 95.

By Captain *Fairfax* of the Navy.

Five species of Fishes from the Spanish main. No. 96.—100.

By the Reverend Dr *Bowmaker*, Minister of Dunfermline.

Two species of Serpents from Florida. No. 101. 102.

By the Right Honourable Lord *Daer*.

A collection of Indian Arms, Apparel and Utensils, from the South Seas ; made during Captain *Cook's* last voyage. No. 103.—177.

A collection of Indian Arms, Apparel and Utensils, and of Natural Productions, made in the South Sea islands, and on the west coast of America, by Mr *Anderson*, Surgeon to Captain *Cook*. No. 178.—274.

By the Earl of *Hopetoun*.

A cabinet of Fossils, containing the following articles :

Fifty-five species and varieties of antique Marbles. No. 275.—338.

Six species of Florentine Marbles and other Landscape Stones. No. 339.—344.

Seventeen species and varieties of the *Phengites*, or antique Oriental Alabafter. No. 345.—411.

Thirty

Thirty-five species and varieties of those antique Stones which are called by the Italians *Pietre dure*. They all belong to the filiceous class, and to the following genera :

List of Donations.

Jasper, *Heliotrope*, *Petrofalex*, *Sinople*, *Lazuli*, *Chalcedony*, *Agate*, *Mocho*, *Jasper Agate*, *Egyptian Pebble*, *Onyx*, *Sardonyx*, and *Camea*.

Nine species of antique *Porphyry*, *Serpentine*, and *Granite*.

No. 539.—554.

Earths, three species. No. 555.—557.

Crystallized *Shorls*, two species. No. 558.—565.

Garnets, three species. No. 566.—569.

Semipellucid Gems, five species. No. 570.—574.

Steatitical Stones, six species and varieties. No. 575.—583.

Amiantus, two species. No. 584. 585.

Zeolitical Stones, four species. No. 586.—598.

Verd d'Ecoffe, Davila, cat. 2. p. 125. n. 4. No. 599.

Nickel and Cobalt, two species. No. 600.—605.

Cubical *Marcasite*. No. 606.

FERRUM *Hæmatites*. β nigrum, LIN. No. 607.

Grey, black and yellow Ores of Copper. No. 608.—616.

Eight species and varieties of Lead Ores. No. 617.—636.

Varieties of Copper Ore. No. 637.—643.

Varieties of Silver Ores. No. 644.—660.

A large mass of green antique *Jasper* polished. No. 661.

An Axe of black Whinstone, supposed to have been used by the Druids in their sacrifices. No. 662.

Petrified Corals from West Lothian. No. 663. 664. 665.

An ancient Amulet, called by the vulgar an *Adder Stone*. No. 666.

Three species of Indian Nuts. No. 667. 668. 669.

Two *Goa* Stones. No. 670. 671.

By John Macgowan, Esq; Edinburgh.

GORGONIA *Norvegica*, the great Norway Sea Shrub. No. 672.

CROTALUS *Dryinas*. LIN. No. 673.

Two

List of Donations.

Two specimens of a large Snake from America. No. 674. 675.
The Roots of an Oak-tree inosculated. No. 676.

By Dr William Gullen.

LACERTA *Bullaris*. LIN. No. 677.

Four species of West India Insects. No. 678.—681.

Five species of West India Serpents. No. 682.—687.

By Mr James Bruce, Edinburgh.

Two species of Scots Birds preserved. No. 688. 689.

By James Boswell, Esq; of Auchinleck.

A collection of West India Animals :

Insects, nine species. No. 690.—698.

Lizards, eight species. No. 699.—707.

Serpents, twelve species. No. 708.—721.

By Mr James Dickson, Bookseller, Edinburgh.

Fourteen Coins of Silver and five of Copper, chiefly Scottish.

By Dr Samoilowitz of St Petersburg.

Memoire sur la Peste qui en 1771 ravagea l'Empire de Russie: Par M. De Samoilowitz: And four other small publications, relative to the same subject.

By Mr Thomas Hutchins.

Experiments for ascertaining the point of Mercurial Congelation.
8vo. Lond. 1784.

By Dr Hutton of Woolwich.

Mathematical Tables. 8vo. Lond. 1785.

An authentic Narrative of the Diffensions and Debates in the
Royal Society of London. 8vo. 1784.

By

APPENDIX.

81

List of Donations.

By Dr *Blane*.

Observations on the Diseases of Seamen. 8vo. Lond. 1785.

By Dr *Robert Boyd*.

Judicial Proceedings before the High Court of Justiciary, &c.
4to. Edin. 1779.

By *H. F. A. De Roussel*, M. D. and Professor of Medicine in the University of Caen.

Dissertatio de variis Herpetum Speciebus, &c. 8vo. Cad. 1779.
Recherches sur la petite Vérole. 8vo. A Caen 1781.

By *Joannes-Franciscus Coste*, &c.

De Antiqua Medico-Philosophia Orbi novo adaptanda, Oratio habita in Comitibus Universitatis Virginiae: Jan. 12. 1782.

By *M. Dionis du Séjour*, of the Royal Academy of Sciences of Paris, &c.

Traité Analytique des Mouvements apparens des Corps Célestes.
Tom. 1. 4to. Paris 1786.

By *M. l'Abbé Treffan*, (à Rouen.)

Essai sur la Fluide Electrique, par feu M. le Comte de Treffan, (son Pere.) 2 toms. 8vo. *

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LIST

* Other Donations have been received, a List of which is reserved for Vol. II.

January 1. 1788.

LIST of all the MEMBERS or FELLOWS of the ROYAL SOCIETY of Edinburgh.

I.

MEMBERS upon the List at the first meeting of the PHYSICAL CLASS, Nov. 3. and of the LITERARY CLASS, Nov. 17. 1783.

[N. B. * prefixed denotes a Member formerly of the PHILOSOPHICAL SOCIETY, and † a Member now deceased. P added denotes of the PHYSICAL CLASS, and L of the LITERARY CLASS.]

I. RESIDENT MEMBERS.

A.

Alexander Abercrombie, Esq; Advocate. L.

* *James Anderson*, LL. D. P.

B.

* *Mr Benjamin Bell*, Surgeon. P.

* *Joseph Black*, M. D. Professor of Medicine and Chemistry in the University of Edinburgh. P.

Hugh Blair, D. D. Emeritus Professor of Rhetoric and Belles Lettres in the University of Edinburgh. L.

Robert Blair, Esq; Advocate. L.

John Bruce, M. A. Professor of Logic in the University of Edinburgh. L.

† *Robert Bruce*, Esq; of Kennet, one of the Senators of the College of Justice. P.

George Buchan-Hepburn, Esq; Advocate. L.

(L 2)

May

Resident Mem-
bers.

C.

Ilay Campbell, Esq; now Lord Advocate. L.

John Campbell, Esq; of Stonefield, one of the Senators of the College of Justice. L.

* † *Sir George Clerk-Maxwell*, Baronet, of Pennycuik. P.

John Clerk, Esq; now *Sir John Clerk*, Baronet, of Pennycuik. P.

John Clerk, Esq; of Eldin. P.

William Craig, Esq; Advocate. L.

* † *Andrew Crosbie*, Esq; Advocate. P.

* *Henry Cullen*, M. D. Physician to the Royal Infirmary. P.

Robert Cullen, Esq; Advocate. L.

* *William Cullen*, M. D. Professor of the Practice of Physic in the University of Edinburgh. P.

D.

Sir John Dalrymple, Baronet, one of the Barons of the Exchequer. P.

Andrew Dalzel, M. A. Professor of Greek in the University of Edinburgh. L.

John Davidson, Esq; Clerk to the Signet. L.

† *Sir Alexander Dick*, Baronet, of Prestonfield. P.

* *Andrew Duncan*, M. D. Physician to his Royal Highness the Prince of Wales.

Right Hon. *Henry Dundas*, now Treasurer of the Navy. L.

† Right Hon. *Robert Dundas* of Arncliffe, Lord President of the Court of Session. L. ||

Robert Dundas, Esq; Advocate, now his Majesty's Solicitor-General of Scotland. L.

E.

James Edgar, Esq; Commissioner of the Customs. L.

David Erskine, Esq; Clerk to the Signet. L.

Colonel *James Edmondstone*, of Newton.

Adam

|| Died Dec. 13. 1787, after the List of Deceased Members was printed. See above, p. 46.

F.

- * *Adam Ferguson*, LL. D. Emeritus Professor of Philosophy in the University of Edinburgh. L.
- George Fergusson*, Esq; Advocate, one of the Commissaries of Edinburgh. P.
- James Fergusson*, Esq; of Pitfour, Advocate. L.
- Major-General *John Fletcher-Campbell*. L.
- Sir *William Forbes*, Baronet, of Pitsligo. L.
- Major *Andrew Fraser*. P.

G.

- * *John Gardiner*, M. D. Edinburgh. P.
- Cosmo Gordon*, Esq; one of the Barons of Exchequer. L.
- * Sir *James Grant*, Baronet, of Grant. P.
- William Greenfield*, M. A. Professor of Rhetoric in the University of Edinburgh. P.
- * *James Gregory*, M. D. Professor of the Theory of Physic in the University of Edinburgh. P.
- Right Hon. *John Grieve*, Lord Provost of Edinburgh. L.

H.

- Alexander Hamilton*, M. D. Professor of Midwifery in the University of Edinburgh. P.
- * *James Hamilton*, M. D. Physician to the Royal Infirmary. P.
- † *Robert Hamilton*, D. D. Emeritus Professor of Divinity in the University of Edinburgh. L.
- Robert Henry*, D. D. one of the Ministers of Edinburgh. L.
- John Hill*, A. M. now LL. D. Professor of Humanity in the University of Edinburgh. L.
- * *Francis Home*, M. D. Professor of Medicine and of Materia Medica in the University of Edinburgh. P.
- George Home*, Esq; one of the Clerks of the Court of Session. L.
- John Home*, Esq; of Kilduff. L.

John

Resident Mem-
bers.

- * † *John Hope*, M. D. F. R. S. LOND. King's Botanist in Scotland, and Professor of Medicine and of Botany in the University of Edinburgh. P.
- David Hume*, Esq; Advocate, and now Professor of Scots Law in the University of Edinburgh. L.
- Andrew Hunter*, D. D. Professor of Divinity in the University of Edinburgh. L.
- † *James Hunter-Blair*, Esq; afterwards Sir *James Hunter-Blair*, Baronet. L.
- * *James Hutton*, M. D. Edinburgh. P.

K.

- * *Alexander Keith*, Esq; Clerk to the Signet. P.

L.

- † *William Lothian*, D. D. Senior Minister of Canongate. L.

M.

- * *Allan Maconochie*, Esq; Advocate, Professor of Public Law in the University of Edinburgh. L.
- * *John Macgowan*, Esq; P.
- John Macfarlan*, D. D. Minister of Canongate, and Almoner to his Majesty. L.
- Henry Mackenzie*, Esq; L.
- John Maclaurin*, Esq; Advocate; now one of the Senators of the College of Justice. L.
- William Macleod-Bannatyne*, Esq; Advocate. L.
- Right Hon. *Thomas Miller* of Barskimming, Lord Justice Clerk; now Lord President of the Court of Session. L.
- * *William Miller*, Esq; of Glenlee, Advocate. L.
- Right Hon. *James Montgomery*, Lord Chief Baron of Exchequer. L.
- * *Alexander Monro*, M. D. Professor of Medicine, and of Anatomy and Surgery in the University of Edinburgh. P.

William

William Morehead, Esq; L.

* *John Morthland*, Esq; Advocate. L.

Resident Members.

N.

William Nairne, Esq; of Dunfinnan, Advocate; now one of the Senators of the College of Justice. L.

Fletcher Norton, Esq; one of the Barons of Exchequer.

P.

* *John Playfair*, M. A. now Professor of Mathematics in the University of Edinburgh. P.

John Pringle, Esq; Advocate. L.

Mark Pringle, Esq; Advocate. L.

R.

David Rae, Esq; of Eskgrove, one of the Senators of the College of Justice. L.

James Robertson, D. D. Professor of Oriental Languages in the University of Edinburgh. L.

William Robertson, D. D. Principal of the University of Edinburgh. L.

William Robertson, Esq; Advocate. L.

* *John Robison*, M. A. Professor of Natural Philosophy in the University of Edinburgh. P.

Adam Rolland, Esq; Advocate. L.

* *Mr James Russell*, Surgeon. P.

* *John Russell*, Esq; Clerk to the Signet. L.

* *Daniel Rutherford*, M. D. now King's Botanist in Scotland, and Professor of Medicine and of Botany in the University of Edinburgh. P.

S.

* *Mr William Smellie*, Printer in Edinburgh. P.

* *Adam Smith*, LL. D. F. R. S. LOND. Commissioner of the Customs in Scotland. L.

John

Resident Mem-
bers.

- * *John Steedman*, M. D. Edinburgh. L.
- * *Charles Stuart*, M. D. P.
David Stewart-Moncrieff, Esq; one of the Barons of Exchequer. P.
- * *Dugald Stewart*, M. A. formerly Professor of Mathematics, now of Moral Philosophy, in the University of Edinburgh. P.
- * † *Matthew Stewart*, D. D. Emeritus Professor of Mathematics in the University of Edinburgh. P.
- * *Alexander Fraser-Tytler*, Esq; Advocate, Professor of Civil History, and of Greek and Roman Antiquities, in the University of Edinburgh. L.
- William Tytler*, Esq; of Woodhouselee, Clerk to the Signet. L.

W.

- * *John Walker*, D. D. M. D. Regius Professor of Natural History, and Keeper of the Museum in the University of Edinburgh. P.
- George Wallace*, Esq; Advocate. P.
- * *Andrew Wardrop*, M. D. Edinburgh. P.

V.

- James Veitch*, Esq; of Elliock, one of the Senators of the College of Justice. L.

2. NON-RESIDENT MEMBERS.

A.

- * *William Alexander*, M. D. London. P.
- * *John Amyatt*, Esq; King's Chemist, London. P.
- John Anderson*, M. A. F. R. S. LOND. Professor of Natural Philosophy in the University of Glasgow. P.

Mr

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- James Beattie*, LL. D. Professor of Logic and Moral Philosophy, Marischal College, Aberdeen. *L.*
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- Mr John Cook*, Professor of Moral Philosophy in the University of St Andrew's. *L.*
- Patrick Copland*, M. A. Professor of Mathematics, Marischal College, Aberdeen. *P.*
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Aberdeen. L.

James Gillespie, D. D. Principal of New College, St An-
drew's. L.

Thomas Gordon, A. M. Professor of Philosophy, King's College,
Aberdeen. L.

Henry Grieve, D. D. Minister of Dalkeith, and Chaplain in or-
dinary to his Majesty. L.

H.

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Marischal College, Aberdeen. P.

William Hamilton, M. D. Professor of Anatomy in the Univer-
sity of Glasgow. P.

George Hill, A. M. now D. D. Professor of Divinity in the
University of St Andrew's. L.

John Hunter, A. M. Professor of Humanity in the University
of St Andrew's. L.

George

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L.

John Leslie, A. M. Professor of Greek, King's College, Aberdeen. L.

* *James Lind*, M. D. Haflar Hospital. P.

* *James Lind*, M. D. Windsor.

Reverend Mr *John Logan*, formerly Minister of South Leith. L.

* *Andrew Lumisden*, Esq;

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Hugh M'Leod, D. D. Professor of Church History in the University of Glasgow. L.

Roderick M'Leod, A. M. Sub-Principal of King's College, Aberdeen. P.

John Main, D. D. Minister of Newton. L.

* *Donald Monro*, M. D. London. P.

* *John Mudie*, M. D. Montrose. P.

O.

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R.

William Richardson, A. M. Professor of Humanity in the University of Glasgow. L.

Thomas Reid, D. D. Emeritus Professor of Moral Philosophy in the University of Glasgow. L.

(M 2)

Reverend

Non-Resident
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* *John Roebuck*, M. D. Kinneil. P.

John Ross, M. A. Professor of Oriental Languages, King's College, Aberdeen. P.

S.

George Skene, A. M. Professor of Natural History, Marischal College, Aberdeen. P.

Robert Small, D. D. Minister of Dundee. P.

† *Hary Spens*, D. D. Professor of Divinity in the University of St Andrew's. L. ||

* *Edward Stevens*, M. D. Barbadoes. P.

* *Alexander Stevenson*, M. D. Professor of Medicine in the University of Glasgow. P.

* Reverend Mr *John Stewart*, Minister of Lufs. L.

George Stuart, LL. D. Emeritus Professor of Humanity in the University of Edinburgh. L.

Right Hon. *James Stuart-Mackenzie*, Lord Privy-Seal.

John Stuart, A. M. Professor of Greek, Marischal College, Aberdeen. L.

T.

* *William Trail*, D. D. Prebendary of Down. P.

V.

Nicholas Vilant, M. A. Professor of Mathematics in the University of St Andrew's. P.

W.

James Williamson, D. D. Professor of Mathematics in the University of Glasgow. P.

* † *Alexander Wilson*, M. D. Professor of Practical Astronomy in the University of Glasgow. P.

Charles

|| Died Nov. 27. 1787, after the List of Deceased Members was printed. See above, p. 46.

Charles Wilson, D. D. Professor of Hebrew in the University of St Andrew's. L.

Non-Resident
Members.

Patrick Wilson, A. M. and now Professor of Practical Astronomy in the University of Glasgow. P.

* *William Wright*, M. D. from Jamaica. P.

Y.

John Young, A. M. Professor of Greek in the University of Glasgow. L.

3. FOREIGN MEMBERS.

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Foreign Mem-
bers.

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* *Father Giam Batista Beccaria*, Professor of Natural Philosophy in the University of Turin.

* *M. le Comte de Carburi*, first Professor of Medicine in the University of Turin.

* *M. Fougereux de Bondaroy*, of the Royal Academy of Sciences, Paris, and of the Institute of Bologna.

* *Benjamin Franklin*, Esq; LL. D.

* *William Franklin*, Esq;

* *M. le Comte de Lauraguais*.

* *John Rogerson*, M. D. first Physician to the Empress of Russia.

* *M. Sue, senior*, of the Royal Academy of Surgery at Paris.

Ordinary.

* *P. Camper*, M. D. Holland.

* *Lionel Chalmers*, M. D. South Carolina.

* *Matthew Guthrie*, M. D. St Petersburg.

* *Lorentz Grell*, M. D. Professor of Chemistry at Helmstadt.

* *Alexander Gordon*, M. D. South Carolina.

MEMBERS

II.

MEMBERS chosen since the first Meetings of the Classes.

Members chosen,
Jan. 26. 1784.

THE following were elected at the General Meeting of the Society, Jan. 26. 1784, all Ordinary Members:

I. RESIDENT.

Sir *David Carnegie*, of Southesk, Baronet. L.

Sir *James Hall*, of Dunglafs, Baronet. P.

John Clerk, Esq; junior, of Eldin, Advocate. P.

John Drysdale, D. D. one of the Ministers of Edinburgh, Principal Clerk of the Church of Scotland, and Chaplain in ordinary to his Majesty. L.

Mr *William Creech*, Bookseller in Edinburgh. L.

2. NON-RESIDENT.

Thomas Hutchins, Esq; Secretary to the Hudson's Bay Company, London. P.

John Moore, M. D. London. P.

Mr *Matthew Boulton*, of Birmingham. P.

Mr *James Watt*, of Birmingham. P.

Robert Fall, Esq; of Dunbar. L.

Right Hon. *Archibald* Earl of *Dundonald*. P.

Nevil Maskelyne, D. D. Astronomer-Royal. P.

James Robertson, M. D. of Oxford. L.

John Grieve, M. D. P.

The Reverend Mr *Archibald Alison*. L.

Sir *John Henderson*, of Fordell, Baronet. L.

3. FOREIGN.

M. Sue, junior, of the Royal Academy of Surgery, Paris. P.

P. Sim. Pallas, M. D. of the Imperial Academy of St Peterf-
burg. P.

M.

M. And. Jo. Lexell, Professor of Astronomy at St Peterfburg. *P.*
M. le Clerc de Sept Chênes, Secretary of the Chamber and Clofet
 to his Most Christian Majesty, Paris. *L.*

THE following were elected at the General Meeting, June 28.
 1784, all Ordinary Members :

Members chosen,
 June 28. 1784.

I. RESIDENT.

Reverend Mr *Robert Walker*, Minister of Canongate. *L.*
Henry Brougham, Esq; of Brougham-hall. *L.*

2. NON-RESIDENT.

Robert Liston, Esq; LL. D. his Britannic Majesty's Minister at
 the Court of Madrid. *L.*
 Reverend Mr *Matthew Murray*, Minister of North-Berwick. *L.*
 Right Hon. *Edmund Burke*. *L.*
 Reverend Mr *Walter Young*, Minister of Erskine. *L.*

THE following were elected at the General Meeting, June 24.
 1785, all Ordinary Members :

Members chosen,
 June 24. 1785.

I. RESIDENT.

Robert Arbuthnot, Esq; Secretary to the Board of Trustees. *L.*

2. NON-RESIDENT.

Right Hon. *George Earl of Morton*. *P.*
 Right Hon. *Dunbar Earl of Selkirk*. *L.*
 Right Hon. the Lord *Daer*. *P.*
 The Honourable *Charles Greville*. *L.*
 Sir *William Hamilton*, Knight of the Bath. *P.*
James Ramsay, Esq; of Auchtertyre. *P.*

Benjamin

Benjamin Vaughan, Esq; of London. P.

George Young, M. D. Physician to the Military Hospital in the West Indies. P.

James Hare, M. D. East Indies. P.

Members chosen,
Jan. 23. 1786.

THE following were elected at the General Meeting, Jan. 23. 1786, all Ordinary Members :

I. RESIDENT.

Robert Blair, M. D. Regius Professor of Practical Astronomy in the University of Edinburgh. P.

Alexander Millar, Esq; Advocate. L.

2. NON-RESIDENT.

Right Hon. *James Earl of Hopetoun*. L.

Right Hon. the Earl of *Ancram*. L.

Sir *Robert Murray-Keith*, Knight of the Bath. L.

Colonel *William Fullarton* of Fullarton, F. R. S. LOND. L.

Thomas Astle, Esq; F. SS. R. & A. LOND. Keeper of the Records in the Tower of London. L.

Charles Hutton, LL. D. F. R. S. LOND. Professor of Mathematics in the Military Academy at Woolwich. P.

Handyside Edgar, M. D. Jamaica. P.

Members chosen,
Jan. 22. 1787.

THE following were elected at the General Meeting, Jan. 22. 1787, all Ordinary Members :

I. RESIDENT.

William Stewart, Esq; Advocate. L.

George Brown, Esq; Commissioner of the Customs. L.

James Home, M. D. Edinburgh. P.

James

James Finlayson, A. M. Profeffor of Logic in the Univerfity of Edinburgh. L.

2. NON-RESIDENT.

James Playfair, D. D. Minifter at Meigle. L.

Adair Crawford, M. D. Phyfician to St Thomas's Hofpital, London. P.

Thomas Percival, M. D. F. R. S. LOND. at Manchester. P.

John Haygarth, M. B. F. R. S. LOND. at Chefter. P.

3. FOREIGN.

M. le Prefident de Virly, Dijon. P.

John Bacounin, Efq; of Ruffia. L.

(N)

OFFICE-

OFFICE-BEARERS of the SOCIETY.

General Office-Bearers.

GENERAL OFFICE-BEARERS, elected at the first and second General Meetings, holden June 23. and August 4. 1783.

President.

His Grace the Duke of BUCCLEUGH.

Vice-Presidents.

Right Hon. *Henry Dundas.* | *Tho. Miller, Esq;* Ld. Justice-Clerk.

Secretary.

Mr John Robison.

Treasurer.

Mr Alexander Keith.

Counsellors.

*Dr Alexander Monro.**Dr John Hope.**Dr Joseph Black.**Dr James Hutton.**Mr Dugald Stewart.**Mr John Playfair.**Mr Baron Gordon.**Lord Elliock.**Major-Gen. Fletcher-Campbell.**Mr Commissioner Smith.**Dr Adam Ferguson.**Mr John MacLaurin.*

Office-Bearers of the Classes.

OFFICE-BEARERS of the two CLASSES, elected at the Meetings, Nov. 3. and Nov. 17. 1783.

PHYSICAL CLASS.

Presidents.

*Sir James Grant, Bart.**Dr William Cullen.**Sir G. Clerk-Maxwell, Bart. ***Dr Francis Home.*

Secretaries.

*Dr James Gregory.**Dr John Walker.*

LITE-

* March 1. 1784, *Dr Alexander Monro* was elected a President of the Physical Class in the room of *Sir George Clerk* deceased.

LITERARY CLASS.

Prefidents.

<i>Hay Campbell, Esq; Ld. Advocate.</i>		<i>Lord Elliock.</i>
<i>Dr William Robertson.</i>		<i>Dr Hugh Blair.</i>

Secretaries.

<i>Mr Alexander Fraser-Tytler.</i>		<i>Mr Andrew Dalziel.</i>
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THE same OFFICE-BEARERS were continued by re-election till Nov. 27. 1786, when, in consequence of a new regulation, all the Office-Bearers were elected on that day, the election to be continued, at a General Meeting annually, upon the last Monday of November.

OFFICE-BEARERS of the Society, elected for the ensuing year, Nov. 27. 1786, and re-elected Nov. 26. 1787.

Prefident.

His Grace the Duke of BUCCLEUGH.

General Office-Bearers.

Vice-Prefidents.

Right Hon. <i>Henry Dundas.</i>		<i>Lord Dunfinnan.</i>
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Secretary.

Mr John Robison.

Treasurer.

Mr Alexander Keith.

Counfellors.

<i>Dr James Hutton.</i>		<i>Lord Elliock.</i>
<i>Mr George Fergusson.</i>		<i>Major-Gen. Fletcher-Campbell.</i>
<i>Mr Benjamin Bell.</i>		<i>Mr Commissioner Edgar.</i>
<i>Mr Dugald Stewart.</i>		<i>Mr William Miller.</i>
<i>Mr John Playfair.</i>		<i>Dr Adam Ferguson.</i>
<i>Dr Daniel Rutherford.</i>		<i>Mr John Maclaurin.</i>

PHYSICAL

Office-Bearers
of the Classes.

PHYSICAL CLASS.

Presidents.

Dr *William Cullen.*
Dr *Francis Home.*

Dr *Alexander Monro.*
Dr *Joseph Black.*

Secretaries.

Dr *James Gregory.*

Dr *John Walker.*

LITERARY CLASS.

Presidents.

Mr *Baron Gordon.*
Mr *Commissioner Smith.*

Dr *William Robertson.*
Dr *Hugh Blair.*

Secretaries.

Mr *Alexander Fraser-Tytler.*

Mr *Andrew Dalzel.*

END OF THE HISTORY.

TRANSACTIONS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. I. PART II.

PAPERS READ BEFORE THE SOCIETY.

THE AMERICAN

REPUBLICAN

OF THE

UNITED STATES

1877

I.

PAPERS OF THE PHYSICAL CLASS.

I. EXPERIMENTS *on the Motion of the SAP in TREES.* By
JOHN WALKER, D.D. M.D. F.R.S. EDIN. and *Regius Pro-*
fessor of Natural History in the University of EDINBURGH.

[*Read by the Author, Dec. 8. 1783, and Jan. 5. 1785.*]

THE discovery of the circulation of the blood in animals was soon followed by conjectures concerning the existence of a like circulation in the sap of vegetables. These conjectures gave rise to the first improvements in vegetable physiology, which may be dated from the appearance of a set of queries concerning the motion of the juices of plants, published in the Philosophical Transactions, *anno* 1668. These queries immediately engaged Dr BEALE and Dr TONGE, and afterwards Dr GREW, Mr WILLOUGHBY, Mr RAY, and Dr LISTER, to enter upon the subject; who, in a great variety of observations, struck out the first considerable discoveries in the vegetable œconomy.

THEIR observations, however, fell short either of proving or disproving a circulation of the sap: Nor have the discoveries of a variety of Philosophers, since that time, been able to demonstrate either side of the question; which still remains a controverted and undetermined point in the history of vegetation.

To trace the progress of the sap, in the way of experiment, seems to be the only method by which we can expect to arrive
at

at a satisfactory solution of this intricate question. For this purpose, those trees which are said to bleed are the most convenient; or those which, at a certain season of the year, have such an exuberance of sap, that it flows freely from them upon a slight incision. *PLINY** mentions twice the bleeding of the mulberry; but he speaks of it as an extraordinary phenomenon, and seems to have been unacquainted with the bleeding of the vine. The trees of this sort are indeed more frequent in the cold than in the warmer climates. Some trees of our own country do not bleed, such as the *oak*, *ash*, *elm*, *aspen*, *hazel*, and *hawthorn*. Of those that bleed, the birch and the plane are the most remarkable; and upon these the experiments here related were performed.

IN the last age, the following important query was proposed on this subject by Dr *LISTER*†:

“WHETHER or not does the sap begin to move in all the parts of a tree at a time?”

FIFTY years afterwards, this question, still unresolved, was again resumed by Dr *HALES*‡, who, in arguing against the circulation of the sap, expresses himself thus:

“IF, says he, early in the spring, the oak, and several other trees, were to be examined near the top and bottom, when the sap first begins to move, so as to make the bark easily run or peel off, I believe it would be found, that the lower bark would be first moistened; whereas the bark of the top-branches ought first to be moistened, if the sap descends by the bark.”

OF late years, M. *BONNET*, when reasoning in favour of a circulation, and against this supposition of Dr *HALES*, delivers the following remarks:

“Is it easy, says he, exactly to fix the time when the sap begins to rise in trees? That fluid rises at first in very small quantity;

* Nat. Hist. lib. xvi. cap. 38.—Lib. xxiii. cap. 7.

† Philos. Transf. anno 1671, p. 2122.

‡ Vegetable Statics, vol. i. p. 141.

“ quantity ; its progress is always rapid ; it speedily reaches the
“ tops of the branches, from whence it quickly passes again to-
“ wards the roots *.”

BUT after the doctrine of the circulation of the sap has been agitated for above a century past ; after so many observations, and such lengthened philosophical discussions upon the subject ; is it not surprising that this enquiry, first started by Dr LISTER, and since suggested by Dr HALES, should have been so much overlooked, and should still remain undetermined by experiment, when it is evidently the previous and leading enquiry on the subject ?

M. BONNET, indeed, in the above passage, seems to think, that the decision of this question by experiment must be extremely difficult, if not impracticable. But that this is far from being the case, will appear from the sequel of the present paper.

THE principal experiment here recorded was therefore made, in order to know whether all the parts of a tree bleed at once, or by succession : How far the ascent and diffusion of the sap depends on the temperature of the air : To trace the route which it observes, and to obtain satisfaction concerning what is called its *recidivation*, and in several other particulars relative to its movement.

FROM this experiment also, some light was expected concerning a noted problem in vegetation, Why the terminating buds of trees are the first which are disclosed in the spring.

THE tree on which this experiment was made, was a vigorous young birch, thirty feet high, and its stem twenty-six inches in circumference at the ground.

ON the 1st of February, there was a hole bored in the trunk of this tree, close by the ground, and one of its branches cut at the extremity, in order to discover when and where the running of the sap would first appear. This was repeated every
second

* BONNET sur l'Usage des Feuilles, p. 284.

second day till the 5th of March, during which time the tree at both places was always dry.

MARCH 5.

FAHRENHEIT's Thermometer, at noon, in the shade, 46. ; at midnight, 38.

ON this day, which had been preceded by the three warmest days since the 1st of February, when an incision was made in the trunk of the birch, just by the ground, I now found a moisture in the wood, not to be perceived before, which made my finger sensibly wet ; but there was no more moisture in the bark than formerly. The extremities of the branches were cut, and found likewise dry.

NOTE 1. THIS day, twenty-one triangular and equilateral incisions were cut in the trunk of the tree, on the north side. The base of these triangles was an inch long, and the incision itself an inch deep, both the bark and wood being taken out. These incisions reached from the ground to the height of twenty feet, and were exactly one foot distant from each other.

2. By *incision*, when not otherwise described in these experiments, is meant a section through the bark into the wood.
3. WHEN an incision does not communicate any sensible moisture to the finger, it is said to be dry ; and moist, when it makes the finger sensibly wet. By *bleeding* is meant such a copious flow of the sap as is sufficient to form a drop or stream from an incision.
4. By the *sap* is meant the lymph, the watery or alimental sap of a tree, and not any peculiar, proper, or venal juice ; being the general fluid from which the peculiar milky, gummy, or resinous juices of trees are formed by secretion, and in a way similar to the secretion of the different animal fluids from the general mass of blood.

MARCH

MARCH 8.

Thermometer, at noon, 44. ; at midnight, 35.

THE lowest incision upon the tree was moist in the wood, as on March 5. but the bark was dry, and no moisture appeared in any of the upper incisions.

EXPERIMENT I. This day, I cut the extremities of one of the branches. Both wood and bark were dry as formerly; but the sap issued visibly between the wood and bark. It stood in small globules, but was not sufficient to form any drop.

COROLLARY I. Here it appears, as it did on several other occasions, that the sap rises between the wood and the bark to the extremities of the branches, before it reaches those parts either by the wood or the bark; yet it is denied by Dr GREW and M. BONNET, that the sap ever ascends at all between the wood and the bark.

MARCH 9.

Thermometer, at noon, 45. ; at midnight, 38.

MARCH 10.

Thermometer, at noon, 46. ; at midnight, 40.

LITTLE farther change was observed on these days; only the lowest incision upon the tree was more moist than formerly, and the second incision, a foot higher, began likewise to appear moist. The sap also between the wood and the bark in the young branches was still more visible, while the wood and bark themselves were dry.

MARCH 11.

Thermometer, at noon, 49. ; at midnight, 44.

THIS day, the lowest incision upon the tree at the ground, and the second, a foot above it, did, for the first time, begin to bleed. The third incision was only moist, and all above it were dry, as formerly,

formerly; only shewing a little more moisture between the wood and bark.

OBSERVATION 1. The sap then on this day, which was the warmest since the 1st of February, with bright sun-shine, had risen a foot, or a little more, in the trunk of the tree, so as to bleed at an incision.

OBS. 2. At this incision, a foot from the ground, the sap flowed only from the wood. The bark, which was of a considerable thickness, was quite dry, and not a drop was formed till the wood was penetrated. The moisture between the wood and bark was indeed considerable, but not sufficient to bleed.

EXP. 2. This day incisions were made upon another birch, which was found to bleed copiously, both in its trunk and branches. The sap, therefore, in this tree was farther advanced, by several days, than in that which was the chief object of our experiments. The latter rose in one trunk, and stood in a thin foil and exposed situation. The former was a younger tree, had a great number of luxuriant suckers, consequently more vigorous roots, and was placed in a deep rich soil, in a low warm part of the wood. To these differences may be attributed the more forward ascent of the sap in this tree above the other.

EXP. 3. A little past six o'clock in the evening, when the sun was set, the two incisions which bled at mid-day were dried up; nor did the sap issue at a new incision made a foot from the ground. But an incision made at that height in the other tree, through which the sap was wholly diffused, still bled.

MARCH 12.

Thermometer, at noon, 49. ; at midnight, 41.

THE two lowest incisions bled as on the former day; and the third incision, two feet from the ground, began to bleed for the first time; but the fourth incision, and those above it, were still dry, as were all the branches.

OBS. 3.

OBS. 3. When the birch is in a bleeding state, no sap issues upon incision, till the knife has penetrated through the bark. The sap then appears in such plenty, between wood and bark, as to run; and runs still more plentifully if the incision passes into the wood. But not a drop of sap can be made to issue from the bark, whatever way it is cut.

OBS. 4. It appears, that, in the beginning of the bleeding season, when the thermometer, at noon, is about 49. or between 46. and 50. and at midnight about 42. or between 40. and 44. that the sap rises about one foot in twenty-four hours, in the trunk of the birch, if not formerly raised by a greater heat.

By other trials, it was found, that, in the same season, when the thermometer, at mid-day, is about 45. and, at midnight, about 38. the sap then ascends only about one foot in two days; and that it does not ascend at all unless the mid-day heat is above 40.

MARCH 13.

THE incision one foot high bled; but the incision two feet high, and all above it, were dry.

Thermometer, at noon, 44. ; at midnight, 42.

OBS. 5. It is here observable, that the incision two feet high was this day dry, although it had bled the day before. The cause is obvious from the thermometer. The cold of 41. during the preceding night, had bound up the sap; and the heat of 44. during the day, was not able to make it bleed at the height to which it had been advanced by the heat of 49. on the preceding day.

MARCH 14.

Thermometer, at noon, 48. ; at midnight, 45.

THIS day the fourth incision, at the height of three feet, began to bleed; the fifth was moist, but all above it were dry as formerly.

B

OBS. 6.

OBS. 6. The incision, one foot from the ground, bled in the evening, more than an hour after the two incisions above it were dried up.

OBS. 7. This day, the bark would not peel off the young branches of the tree; but the *epidermis* separated more freely from the bark than formerly.

MARCH 15.

Thermometer, at noon, 52.; at midnight, 44.

Thermometer, at noon, in the sun, 67.

THE fifth incision, four feet high, bled for the first time; but the sixth incision, and all above it, still refused to bleed; yet the sixth was more moist than formerly, especially between wood and bark.

OBS. 8. It was now found, that the incisions did every day cease to bleed upon the removal of the sun, the uppermost giving over first, and the rest successively downwards. The sap had now risen in the tree to the height of four feet. The fifth incision ceased to bleed this day at three in the afternoon. The four incisions below it gave over bleeding one after another, and were all dry at five o'clock; the sun having become clouded, and the thermometer fallen to 44.

MARCH 16.

Thermometer, at noon, 47.; at midnight, 37.

THE five lowest incisions bled as on the former day; but the sixth still continued dry.

COR. 2. It appears, that the sap will not rise much higher by the heat of 47. than it did on the preceding day by the heat of 52. but will maintain its ascent, and bleed at the same height.

MARCH

MARCH 17.

Thermometer, at noon, 44. ; at midnight, 42.

THE four lower incisions bled this day. The fifth, which had bled on the two preceding days, was only moist.

COR. 3. When the thermometer falls to 44. the sap cannot run at the same height at which it ran when the thermometer was at 47.

OBS. 9. It was now observed, and always found to be the case afterwards, that each incision bled sparingly at first, and more plentifully as the sap ascended higher. The most copious flow of the sap was always from the lowest incisions. When the birch tree, therefore, is to be pierced, in order to procure a large quantity of its sap, it will be found proper to make the incisions as near the ground as possible.

MARCH 18.

Thermometer, at noon, 47. ; at midnight, 42.

THE five lower incisions bled, as on the former days ; but the sixth still continued dry.

OBS. 10. The sap, by the temperature of the air, is capable of remaining long stationary. During the four last days, it stood nearly at the height of four feet, without ascending farther. In another experiment, the sap continued stationary for five days, at the height of two feet, the thermometer, during that time, never being above 43. at noon, nor above 36. at midnight.

MARCH 19.

Thermometer, at noon, 48. ; at midnight, 41.

Thermometer, at noon, in the sun, 65.

THE sixth incision did this day bleed for the first time ; the seventh was moist, and the rest dry. But though the incisions in the trunk above the sixth, and some that were made in the branches, did not bleed ; yet they did all along gradually and visibly increase in moisture.

COR. 4. Hence we find, that a tree does not become suddenly replete with sap, as has been generally thought. The sap does not mount into a tree by one, but by several successive tides. The most copious of all these, and the most remarkable, is that which brings on the bleeding. It is this tide, whose progress we trace in the present experiment; but it is evidently preceded by several lesser ones, which communicate a moisture to the tree, though not in such quantity as to bleed.

THAT a degree of sap ascends in trees immediately upon the falling of their leaves, appears from the vegetation of catkins, during winter, upon the birch, the alder, and the hazel. But in autumn, the trees are left so devoid of sap, by the expence of the former summer and the fall of the leaf, that it is not till spring, and the return of a sufficient degree of heat, that they become so impregnated with sap as to be capable of bleeding.

MARCH 20.

Thermometer, at noon, 44. ; at midnight, 43.

THE fifth incision bled, and those below it; but the sixth, which had bled the day before, and all above it, were dry.

EXP. 4. On this day, and on several other occasions, an incision made on the south side of the tree bled always more plentifully than an incision at the same height on the north side.

COR. 5. The ligneous circles in the trunks of trees are commonly eccentric, the centre of the circles being placed at a distance from the centre of the tree. M. DU HAMEL ascribes this eccentricity to the casual insertion of roots, and the irruption of branches, which determines the sap to move in greater abundance on one side of the tree than another. And it is unquestionable that this sometimes happens. But when the centre of these circles stands nearer the north than the south side of the tree, and the circles themselves on the south side are considerably broader than those on the north, which is usually the

the case, the eccentricity is to be ascribed to a different and more general cause, which is pointed out in the above experiment.

FOR as there is a more copious flow of the sap on the south than on the north side of trees, owing to the one being more in the sun, and the other in the shade, this must naturally affect the shape of their trunks; the sap on the south side being more plentiful, there the growth of the wood must, of course, be more considerable. And this again suggests the reason, why the wood on the north side of a large tree is often found harder and more durable than that on the south side; because it is of a slower growth, and consequently of a more compacted substance.

MARCH 21.

Thermometer, at noon, 48. ; at midnight, 43.

Thermometer, at noon, in the sun, 60.

THE seventh incision bled to-day for the first time; the eighth was a little moist, but all above it were still dry.

OBS. 11. So far up as the tree bled, which was now six feet, the bark separated easily from the wood, and a great deal of moisture appeared between them. Above this, the space between the wood and bark grew gradually drier, and the bark was, with more difficulty, separable from the wood. Upon many trials, it was found, that, in the birch, the bark separates from the wood upon the sap's ascent, and not before; nor any higher than where the sap will stream upon incision; and that wherever the tree will bleed, there the bark not only parts easily from the wood, but the *epidermis* separates readily from the bark, the teguments of the bark from one another, the *alburnum* both from bark and wood, and even the ligneous circles are rendered easy to be detached from one another.

COR. 6.

COR. 6. As the ascent of the sap thus renders all the strata of a tree easily separable; and as this is the case in the lower parts of the tree, so far as the sap has ascended, while these parts remain firmly attached to one another in the upper parts of the tree, to which the sap has not ascended; it is therefore evident, though contrary to what is generally supposed, that this phenomenon is occasioned by the sap in its ascent, and not by any return of the sap downwards from the extremities of the tree.

COR. 7. As the ligneous circles, during the ascent of the sap, do thus subsist in a loose and unconnected state, the felling of timber, during that period, ought by all means to be avoided. This period of the sap's ascent varies considerably in different trees. In the plane, it may be dated from the 25th of December to the 25th of March; in the birch, from the 1st of March to the 26th of April; in the oak, from the 20th of March to the 1st of June; and it would be of use, were the period of the ascent of the sap ascertained in like manner in the other forest trees. The oaks, which are cut for their bark in April and May, during the ascent of the sap, afford a soft and perishable timber, compared to those which are cut in the depth of winter. And the same is the case with all the plane-trees cut in the months of January and February, compared to those which are cut in the month of November. To obtain timber in its greatest perfection, I believe it cannot be cut too soon after the fall of the leaf, as it is then in its most sapless state, and the ligneous circles more firmly compacted than at any other season.

MARCH 22.

Thermometer, at noon, 45.; at midnight, 40.

THE seven lower incisions bled as on the former day; the eighth was wet, but all the upper ones remained dry.

OBS. 12.

OBS. 12. On the day an incision began to bleed, the one immediately above it appeared always moister than formerly. This moisture appeared first, and in greatest quantity, between the wood and bark, and always shewed itself first on the lowest side of the incision.

OBS. 13. At whatever height an incision bled, all the incisions below it constantly did so at the same time.

MARCH 23.

Thermometer, at noon, 46. ; at midnight, 42.

Thermometer, at noon, in the sun, 68.

THE eighth incision, which was seven feet high, bled for the first time ; the ninth was moist, but all above it dry.

OBS. 14. At $7\frac{1}{2}$ feet high stood the first branch upon the tree, marked A*, which was about three feet long. It was this day cut at the extremity, and was found very moist, but not so as to form a drop. The next branch above it, marked B, was placed eight feet high, and was eight feet long. This, being also cut at the extremity, was found drier than the former.

MARCH 24.

Thermometer, at noon, 47. ; at midnight, 35.

THIS day the ninth incision began to bleed ; the tenth was moist, but those above it dry as formerly.

EXP. 5. The sap having now mounted to the juncture of several branches, the branches B and C were cut at the extremity, but without bleeding. The branch D was also cut at the extremity, and, in like manner, refused to bleed. But when this branch was bent down into the perpendicular direction D E, and kept so bent by the cord G H, the incision at the extremity did then begin to bleed, and in five minutes continued to drop. Yet the branch below it C, that remained in its lateral position, had its incision at the extremity still dry.

COR. 8.

* *Vide* Plate I. Fig. 1.

COR. 8. The motion of the sap then is accelerated by the perpendicular position of the branches; a leading fact, not only in the motion of the sap, but in the structure of the vessels which convey it. And from which at present we may thus far conclude, that the motion of the sap of trees is not the same with that of fluids in capillary tubes, as has been generally thought, but descends with a greater force than it ascends; and consequently its motion must depend upon some different principle.

COR. 9. From this experiment we may likewise infer, that the sap makes its way sooner, and in greater quantity, to the extremity of pendent than of erect branches. Hence the reason appears, why the gems upon pendent branches always burst sooner than upon those which are in an upright position. And it is probably also for the same reason, that most fruits are of a brisker growth, and of a larger size, upon those branches which hang down, than upon such as are erect.

OBS. 15. In the branches, A, B, C, D, to which the sap had now ascended, we remarked a considerable alteration in the buds, though very little change had been observed in them for six weeks before. They now began to swell, and their scales to shoot from under one another; but the buds upon the superior branches, to which the sap had not yet ascended, were not so swelled, but compact as formerly.

MARCH 25.

Thermometer, at noon, 42.; at midnight, 34.

Continued sun-shine all day. Thermometer, in the sun, at noon, 63.

THE ninth incision continued to bleed, but all the superior incisions were dry.

OBS. 16. The inverted branch D E continued this day to bleed at the section E, while the branches B and C, placed below it, but in their natural position, were only moist at their extremities.

OBS. 17.

OBS. 17. At five o'clock in the afternoon, the ninth, eighth, and seventh incisions had ceased to bleed; but still the inverted branch, though placed above them, bled at the extremity, and continued to do so till it was dark, when all the other incisions upon the tree were dried up.

To observe the effects of an inverted position of the branches upon the motion of the sap, the two following experiments were also made :

EXP. 6. On the 1st of March, two branches of a birch, the one placed five, and the other fifteen feet high, were tied down with their extremities pointing directly to the earth. The buds on these two inverted branches swelled larger, broke sooner, and threw out larger leaves, than any other buds upon the tree.

EXP. 7. At the same time, and in the same manner, two other branches of a birch were inverted, in every respect similar to each other. All the extremities of the one were cut; but those of the other were left entire. That branch whose extremities were cut, continued to drop at every twig during the whole bleeding season; yet the buds upon this branch swelled larger and broke sooner than those upon the other branch, which had been suffered to remain entire.

COR. 10. From these experiments, I shall only draw this obvious, though not unimportant conclusion, That wherever the ascending sap moves most freely, and in the largest quantity, there, the buds swell to the largest size, and disclose themselves soonest.

OBS. 18. At five this afternoon, the ninth incision, eight feet high, on the north side of the tree, was dried up; yet an incision, at the same height, on the south side, continued to bleed till sunset, and was bleeding when the incision, only six feet high, on the north side, was become quite dry.

COR. 11. This observation suggests a fact, relative to the cause of the sap's motion, which deserves to be noted: That the motion and bleeding of the sap does not proceed from a force

C

communicated

communicated to it from the root, but from the action of heat. The south side of the trunk was this day far more considerably heated than the north side; and therefore, in the evening, we found it bleed on the south side, at the height of eight feet, when it refused to bleed, at the height of six feet, on the north side.

MARCH 26.

Thermometer, at noon, 39. ; at midnight, 36.

THE seventh incision bled; but the eighth and ninth were dry, though they had bled the two former days.

OBS. 19. On this day, and at all other times, whenever an incision bled on the trunk of the tree, all the incisions below it bled likewise.

OBS. 20. In the course of this experiment, we have found the uppermost incision sometimes dry, though it had bled the day before; but here we find the two uppermost incisions dry, which had bled the two former days. The cause is evident from the thermometer, which this day stood lower than on any of the preceding days of observation.

AT this season, so like is the sap in a tree, to the fluid in a thermometer, and so dependent in its motion on the heat and cold of the atmosphere, that, by looking at the thermometer before I went abroad, I came now to guess nearly the height at which I should find the tree bleeding.

OBS. 21. The inverted branch DE bled this day plentifully at E, though the two incisions below it refused to bleed; as did also the branches below it, which were in their natural position.

COR. 12. If at any time we would wish to obtain a large quantity of the sap of the birch, or of any other bleeding tree, it would appear, therefore, to be a useful practice, to bend the branches into a perpendicular position, and to cut them at their extremities.

COR. 13.

COR. 13. We find, that when the parts of a tree are not fully replete with sap, they will bleed with a certain degree of heat, but will refuse to bleed with a smaller degree: That the more a tree is replenished with sap, the less degree of heat is necessary to make it bleed, and *vice versa*. On the 13th of March, the third incision refused to bleed with the heat of 44.; but on this day, the seventh incision bled with the heat of 39.

MARCH 27.

Thermometer, at noon, 45.; at midnight, 40.

THE eighth incision bled; but the ninth, which had bled formerly, was dry. The inverted branch continued to bleed at its extremity E.

MARCH 28.

Thermometer, at noon, 49.; at midnight, 43.

THE eighth incision bled; but the ninth was dry, as on the preceding day. The inverted branch continued to bleed plentifully at its extremity.

OBS. 22. The buds on the inverted branch were now swelled to a larger size, and were evidently more forward than any others upon the tree, though this was only the fifth day since the branch was placed in that posture.

EXP. 8. On the 23d instant, I had cut seven incisions, a foot distant from each other, upon the branch B. These incisions were cut deep, near to the pith of the branch, perpendicular to the horizon, and were made with a view to solve the two following queries:

1. WHETHER the sap makes a swifter progress in young than in old wood? And,
2. WHETHER, at this time, there was any descending sap to be discovered in the tree?

THE experiment upon this branch afforded full satisfaction concerning both these questions.

As to the first, the sap had issued on the 24th instant at the ninth incision, which was just below the infertion of this branch, but had been kept from ascending higher, for three days past, by a great degree of cold. During these days, I watched every morning to find when the sap would appear at the lowest incision upon the branch; but the cold was too great to suffer it to make any progress till this day. Accordingly, all the seven incisions on the branch did this day bleed successively, from the bottom to the top, between nine o'clock in the morning and two in the afternoon.

COR. 14. In answer to our first enquiry, we therefore find, that the sap moved in this young branch seven feet in one day; but when the thermometer was at the same degree of 49. the sap moved in the trunk of the tree only at the rate of seven feet in seven days. We may therefore, in general, conclude, that the sap makes a swifter progress in young than in old wood; and that, in some cases, the proportional difference is no less than seven to one.

ON the 16th of March, the birch on which this experiment was made, being about thirty feet high and thirty-five years old, bled no higher than four feet above the ground; but a younger birch, standing close by it, being only about fourteen years old, did, on that day, bleed at the top, or fifteen feet high. Many such instances might be adduced to shew, that the sap runs more freely, and with a quicker ascent, in young than in old wood. In consequence of this, the young trees of every species, *cæteris paribus*, disclose their leaves in spring sooner than those which are old.

OBS. 23. As to the second enquiry, the first bleeding of these seven incisions on the branch B was attentively marked, that I might know whether the sap would first appear on the under or upper side of each incision, or on both at the same time. Accordingly, this morning, the sap made its first appearance upon the lowest side of the lowest incision, at h; and so successively,

cessively, upon the lower side of all the other incisions, marked i, and flowed plentifully, while the upper side of all the seven incisions, marked k, remained dry.

COR. 15. The result of these trials then amounts to this: That there was at present no descending sap from the branches: That the whole sap of the tree was in an ascending state: That it had now reached about nine feet high in the trunk; beyond which height it was still dry, and refused to bleed.

BEING assured of this, I now applied myself to examine an experiment of M. DU HAMEL, upon which he founds his doctrine of a descending sap in the bleeding season.

EXP. 9. This experiment was made, by sawing two inches deep into the tree, at L, one foot from the ground. Another incision, of the same depth, was made three inches below, both being horizontal; and the wood and bark between the two were completely extracted. The sap was then perceived to flow as plentifully from the surface of the upper incision at m, as from that of the under incision at n.

COR. 16. From this experiment, M. DU HAMEL* supposes, that, in the bleeding season, there is not only an ascending but a descending sap. Finding the sap to issue from both incisions, he concludes, that it moves at the time in two different directions, or both upwards and downwards. The facts which he delivers in the above, and in other experiments, which I also repeated, are certainly true; but this conclusion which he draws from them is unquestionably erroneous.

It is evident, from the whole train of our experiment, that, from the earliest spring to the present day, the 28th of March, all the sap which flowed in the birch was in an ascending state, and that there was no descending sap whatever from the extremities of the tree towards the root. But when once any part of a tree comes to be replete with this ascending

* *Physique des Arbres*, tom. i. p. 66.

ing sap, we find it will run out in any direction, either upwards or downwards, wherever an incision is made.

MARCH 29.

Thermometer, at noon, 46. ; at midnight, 42.

THE eighth incision bled ; but the ninth was still dry. The inverted branch bled still freely at E. The seven incisions on the branch B did not bleed.

OBS. 24. Dr TONGE *, in the last century, first noticed what he termed the *recidivation* of the sap, that is, its subsidence or descent in a tree during the cold of the night. This opinion was also adopted by Dr HALES †, who says, " That the sap " in all vegetables does probably recede, in some measure, " from the tops of branches, as the sun leaves them." It is an opinion that has since been generally admitted, and the phenomenon itself termed the *ocillatory motion* of the sap.

SUCH a motion of the sap, however, appeared very questionable, on several occasions, in the course of our present experiment. Often, when the sap was risen to a considerable height in the tree, the incisions which had formerly bled would be found dry in a cold morning ; but a warm gleam of the sun would, of a sudden, set them a-bleeding, not successively, but all at once. This seems to prove, that the sap does not descend when the incisions cease to bleed by an increase of cold, but is only bound up.

To verify or invalidate this conclusion, the following experiments were made :

EXP. 10. March 28. A luxuriant young birch, two inches in diameter, was this day cut over, a foot above ground. Being cut at mid-day, both sections bled for two hours ; but the under one more plentifully than the other. The upper section became quite dry on the approach of night. The tree

* Philos. Transf. anno 1668. p. 855.

† HALES Staticks, vol. i. p. 145.

tree thus cut, being kept in the same upright position in which it grew, on the two following days it bled a little about mid-day; but on each day it became dry, that is, the sap ceased to descend whenever the cold of the evening began to take place.

EXP. 11. February 10. At four o'clock afternoon, during a keen frost, two branches, each five feet long, were cut off a plane-tree. The under sections bled rapidly, and the sap freezing as it ran, in half an hour there was a long icicle hanging at each section. The two separated branches, being kept perpendicular in the open air for half an hour, appeared only moist at the place where they were cut, but did not bleed. One of them being brought into a warm room, bled copiously for an hour. The other having been still kept in the open air, had not separated a drop during that time; but, upon being removed into the room, it bled freely like the former.

COR. 17. From these experiments, we are, therefore, still led to conclude, that the sap does not descend by cold: That when a tree ceases to bleed by an increase of cold, this effect is not produced by a subsiding or descent of the sap; but that, by the cold, it seems only to be arrested and held in a state of stagnation.

THE *recidivation* or *ocillatory motion* of the sap, by the cold of the night, though long held by philosophers, appears, therefore, to be an erroneous opinion, which has little or no foundation in nature.

COR. 18. In the last experiment, we have the force of the sap's motion, and the influence of the cold upon that force, weighed, the one against the other. The freezing cold was not able to prevent the motion of the sap upwards, but was powerful enough to obstruct its motion downwards. Here, as it was found in many other cases, the force of the sap
ascending

ascending at the under section of the branch, was greatly superior to its force in descending at the upper section.

MARCH 30.

Thermometer, at noon, 50. ; at midnight, 43.

THE eighth incision bled ; but the ninth continued dry. The inverted branch still bled freely at E. The under sections of the seven incisions on the branch B bled ; but their upper sections were as yet dry.

OBS. 25. The ninth incision still refused to bleed, though the heat of this day appeared sufficient to elevate the sap to that height ; but between the eighth and ninth incisions, there were two large young branches, which seem to have led off the sap faster than the old wood of the trunk.

OBS. 26. From what has been noticed of the branches D and B, we find, that a young branch bleeds sooner than an incision in the trunk, placed even below the insertion of the branch. This evidently arises from a quicker and more easy flow of the sap in young than in old wood ; by which means, the branch comes to be sooner replete with sap than the adjoining part of the stem.

MARCH 31.

Thermometer, at noon, 62. ; at midnight, 40.

THE seventh incision upon the trunk bled ; but those above it were dry. The section of the inverted branch at E continued to bleed. All the seven incisions upon the branch B were dry.

OBS. 27. When I found the thermometer so much higher this day than it had been at any time during the season, I went out, expecting to find the tree bleeding at a greater height than it had hitherto done : But in this I was disappointed ; for all the incisions above the seventh, even the eighth and ninth, which had formerly bled, were perfectly dry. This was

was the first instance of many which afterwards occurred, to shew, that, in the early spring, a tree bleeds by heat, and, as the season advances, by cold.

APRIL 1.

Thermometer, at noon, 50.; at midnight, 34.

No observation because of rain.

APRIL 2.

Thermometer, at noon, 46.; at midnight, 39.

THE seventh incision, being the one immediately under the branches, bled; but the eighth, and all the other incisions above it, upon the trunk, were dry. The inverted branch D E still bled at E, but not in such abundance as formerly.

OBS. 28. It is remarkable, that the eighth and ninth incisions, which had formerly bled, were dry for some days past, though the four branches above them bled freely. It appears, that, when the sap rises to the juncture of branches, it is there led off rapidly by the younger wood. By this means, the branches become replete with sap; the adjacent parts of the trunk are drained, and cease to bleed; while the sap, in the younger wood of the branches, flows plentifully.

ANOTHER case, analogous to this, was found in the following experiment:

EXP. 12. The grey willow* is a tree which does not bleed; but when the sap ascends in spring, it rises visibly between the wood and bark, though not so copiously as to bleed; yet wherever it arrives in sufficient quantity, it makes the bark separate easily from the wood, as in the birch, and probably in all other trees.

ON the 19th of April, the bark of this tree was found to separate freely from the wood, where the branch was of four years growth. It separated still more freely where the branch

D

was

* *Salix caprea*, LIN.

was only of three or two years growth ; and most readily of all in the last year's shoots. At the same time, the bark refused to separate freely in the above branch, where its growth was seven years old, and was still more adhesive in the trunk, which was about twenty years growth, and half a foot in diameter.

COR. 19. Were it not for the light obtained by the former experiments, we might be led to conclude from this trial, that the sap which appears in spring, between wood and bark, descends from the extremities of a tree towards the root, and probably in a way of circulation : But we have found, that the sap which runs in spring, between wood and bark, ascends directly, and in a very gradual manner, from the root. The result of this experiment, therefore, coincides exactly with the above observation, and shews, that the younger wood does powerfully draw off the sap from the older : That, by draining the trunk, the sap accumulates in the branches ; and that, in young wood, we find a greater quantity of sap than in the older wood through which it has passed in its way from the root.

APRIL 3.

Thermometer, at noon, 49. ; at midnight, 44.

No observation because of rain.

APRIL 4.

Thermometer, at noon, 53. ; at midnight, 44.

THE tenth incision bled this day, but very sparingly. The inverted branch D E bled at E. The incisions on the branch B bled at their under sections, and also at their upper sections, but in much less quantity.

OBS. 29. This last appearance seems to favour the idea of a circulation, if it might be supposed, that the sap, which issues from the upper sections of the incisions, is the effect of a regular return from the upper extremities of the tree. But it
is.

is to be noticed, that, wherever the sap has ascended, the whole body of the wood is replete with it: That, upon incision, it issues from the wood downwards, and in every other direction; and that this happens before any sap has yet arrived at the upper extremities of the tree.

APRIL 5.

Thermometer, at noon, 50. ; at midnight, 41.

APRIL 6.

Thermometer, at noon, 48. ; at midnight, 40.

No observation was made on these days.

APRIL 7.

Thermometer, at noon, 49. ; at midnight, 42.

THE eleventh incision bled ; and the inverted branch bled at E.

APRIL 8.

Thermometer, at noon, 48. ; at midnight, 40.

THE eleventh incision continued to bleed.

APRIL 9.

Thermometer, at noon, 50. ; at midnight, 44.

THE twelfth incision bled this day.

APRIL 10.

Thermometer, at noon, 53. ; at midnight, 49.

THE thirteenth incision began this day to bleed for the first time ; but all the incisions above it were still dry. The inverted branch also bled at E.

OBS. 30. This day I attended carefully to the issuing of the sap, both from the upper and under incisions of the branch B, and found, that it flowed in each incision, both from the ligneous circles, and from between them. It evidently appeared, how-

ever, to flow from the veins separating the circles, before it issued from the circles themselves; which serves to shew, that the sap runs more freely in the one than in the other, as we found before, that it runs more freely between the wood and bark than in the wood itself.

OBS. 31. It was also this day remarked, that, in all the incisions upon the branch B, the sap appeared sooner, and flowed more copiously from the outer than from the inner circles of the wood. To be further assured of this, a number of branches, both of the birch and plane, were cut over, when the same appearance constantly took place, and which confirms the observation formerly made, "That the sap is more expeditiously and plentifully conveyed by young than by old wood."

DURING the 11th, 12th and 13th of April, the thermometer, at noon, stood at 45. 44. and 43. respectively; and, at midnight, at 36. 35. and 39. These degrees of cold arrested the sap. It issued sparingly at the thirteenth incision, and at all the under incisions, but went no higher.

APRIL 14.

Thermometer, at noon, 55.; at midnight, 46.

THE fourteenth incision bled this day for the first time; but all the incisions above it were still dry. The inverted branch also bled.

OBS. 32. It was again carefully observed, by new incisions on the branch B, whether, according to M. DU HAMEL, there was an ascending sap by the ligneous circles, and a descending sap by their veins; but it was found, as formerly, that the sap proceeded from both in the same direction. It issued, indeed, in less quantity, from the upper than from the under sections. When a thin slice of wood was taken off a cicatrised or dried section, the sap issued from the veins before it
made

made its appearance from the circles ; and when the place cicatrised was only in part cut away, the veins would appear moistened with the sap, while the circles themselves remained perfectly dry. These appearances, I imagine, made M. DU HAMEL suppose, that there was a distinct descending sap by these veins. Such appearances do, indeed, at first sight, very naturally lead to this supposition ; but, on farther inspection, must be referred to the cause already established, the more easy and copious flow of the sap between the circles than in the circles themselves.

APRIL 15.

Thermometer, at noon, 49. ; at midnight, 48.

THE fourteenth incision bled as yesterday. The fifteenth was very moist, but did not bleed.

APRIL 16.

Thermometer, at noon, 56. ; at midnight, 50.

THE fifteenth and sixteenth incisions bled this day for the first time.

OBS. 33. In the course of these experiments, this was the first instance in which the sap moved two feet in twenty-four hours. But the thermometer, in the shade, stood higher than it had hitherto been, and there was bright sunshine during the whole day.

APRIL 17.

Thermometer, at noon, 51. ; at midnight, 47.

APRIL 18.

Thermometer, at noon, 50. ; at midnight, 47.

DURING both these days the sixteenth incision bled ; but the seventeenth, though wet, did not bleed. This seemed to be owing to some vigorous young branches which led off the sap, and thereby prevented its rise, for a time, in the stem.

APRIL

APRIL 19.

Thermometer, at noon, 54. ; at midnight, 50.

THE seventeenth incision did, for the first time, bleed.

OBS. 34. When the tree first began to bleed, the streaming of the sap was confined to two, three or four hours, about the middle of the day ; but as the heat of the season advanced, and the tree became more replete with moisture, the running of the sap commenced early in the morning, and continued till very late in the evening. It is likewise to be noticed, that, in the evening, the sap often continued to flow from incisions in the branches, when those upon the trunk were dried up ; and that it also run longer from inverted than from upright branches.

APRIL 20.

Thermometer, at noon, 56. ; at midnight, 49.

THE eighteenth and nineteenth incisions bled to-day, for the first time. There was warm sunshine during the whole day.

APRIL 21.

Thermometer, at noon, 54. ; at midnight, 47.

THIS day the twentieth incision bled.

APRIL 22.

Thermometer, at noon, 52. ; at midnight, 45.

THE twenty-first incision, which was made a few days before, and which was the highest that could be made on the tree, did this day bleed for the first time. It was twenty feet from the ground.

APRIL 24.

Thermometer, at noon, 56. ; at midnight, 50.

THIS day the tree bled, in all its parts, at every incision upon the trunk, and at every twig cut at the extremities of the branches.

APRIL

APRIL 30.

Thermometer, at noon, 60. ; at midnight, 52.

THE *vernation*, or budding of the tree, now took place, that is, the young leaves were shot forth so far, as to be of an equal length with the *hybernaculum*.

THIS day all the incisions, in the upper part of the tree, were dry. A little sap still issued from the four incisions upon the trunk, that were next the ground. But fresh incisions being made in different parts of the branches, they all refused to bleed.

MAY 1.

Thermometer, at noon, 58. ; at midnight, 50.

ALL the incisions, both on the trunk and branches, were dry, excepting one, a foot from the ground, which still continued moist, though it did not bleed.

COR. 20. It appears then, that the sap does first cease to flow in the branches ; and that it continues, for some little time, to flow in the lower parts of the trunk, after the upper parts are become dry.

MAY 2.

Thermometer, at noon, 60. ; at midnight, 53.

INCISIONS being now made over the whole tree, from the root to the extremities of the branches, they were all found perfectly dry. The young leaves were now shot forth in length, considerably beyond that of the *hybernaculum*.

OBS. 35. It seemed now natural to conclude, that the tree ceased to bleed, and that the wood was every where become dry, by the evaporation occasioned by the leaves which were now shot forth. The two following experiments, however, shew, that this appearance is owing to a different cause.

EXP. 13. A young birch, $1\frac{1}{2}$ inch in diameter, was cut over at the beginning of the bleeding season, a foot from the ground, and, on the trunk that remained, there was no bud. This
trunk

trunk continued to bleed during the season, but it gave over bleeding at the same time with the other trees. The wood became dry, the sap flowed between wood and bark, which were then easily separable from one another, and the bark itself became moist, though it had neither buds nor leaves upon it.

EXP. 14. All the buds were stripped off one side of another birch tree and all the buds on the other side, were left entire. Both sides of the tree, however, ceased to bleed at the same time. The wood turned dry, the sap flowed between the wood and bark, and the bark became moist on that side of the tree which was deprived of its buds, in the same manner, and at the same time, in which these alterations took place on the side of the tree which retained its buds, and whose leaves were now considerably expanded.

COR. 21. The drying up of the sap, therefore, in the wood of trees, about the time of their vernalion, proceeds not from the evaporation occasioned by their leaves, but from a general communication and diffusion of the sap from the wood into the bark, at that season. To this cause, likewise, and not to any influence of the leaves, is to be ascribed the running of the sap between the wood and bark, during the season of *vernalion*.

MAY 10.

Thermometer, at noon 63. ; at midnight, 50.

THE leaves of the tree were now expanded, and the wood was every where quite dry. The sap flowed between the wood and the bark, so as to wet the finger, and bled sensibly. The bark did not, in any degree, bleed ; but was every where more moist and succulent than when the sap flowed in the wood. The bark peeled easily from the wood, the alburnum from both, and its fibres were more easily separated from one another than at any period while the sap ran in the wood.

C O N-

C O N C L U S I O N.

IN the course of this paper, many particular observations and corollaries have occurred, respecting the motions of the sap and the vegetation of trees ; but there still remain some general conclusions to be drawn from the whole train of the experiments. As to the truth of the experiments, I can have little doubt, as they were all twice performed in two different years, and some of them repeated on other occasions ; but the justness of the conclusions drawn from them must be entirely submitted to the determination of the Society.

§ 1.

WHETHER or not all the parts of a tree bleed at once, or by succession, is a question that seems to be solved, in a satisfactory manner, by these trials.

WE find the bleeding sap begins first to flow at the root, to ascend slowly upwards, and to bleed successively as it ascends, to the very extremities of the tree.

IN the year in which these experiments were made, the sap required forty-three days, from the 11th of March to the 22d of April, to mount twenty feet high in the trunk of the birch ; that is, upon an average, it ascended nearly six inches each day. During another year, however, the sap was found to rise twenty feet, in the trunk of the same birch, in thirty-three days ; that is, from the 7th of March to the 8th of April, which was about nine inches each twenty-four hours. In another year, the same birch did not begin to bleed at the ground till the 27th of March. Such a variation is to be expected, as the seasons vary ; and to this difference in the bleeding of the sap, is to be ascribed that remarkable diversity, in the time of vernalion, observed by the same tree in different years.

§ 2.

M. DU HAMEL *, who bestows a great deal of attention upon this subject, is dubious, whether the sap of trees, in the bleeding season, be in an ascending or descending state, and is solicitous that the point should be determined by experiment. In answer to this enquiry, it seems clear, by the above trials, that, from the 11th of March, when the sap first began to run at the bottom of the trunk, till the 30th of April, when the tree began to unfold its leaves, the whole sap of the tree was in a progressive state upwards : That it was liable, indeed, to fall back, or to run out, upon incision, in any direction ; but that, during the whole bleeding season, there was no just appearance of any descending, returning, or circulatory sap.

§ 3.

WE may next attend to the tract observed by the sap in its ascent during the bleeding season.

IN none of the experiments here related, could any sap be perceived to arise, either by the pith or the bark. The whole sap was conveyed upwards by the wood, and between the wood and bark ; but beyond this canal, no flow of the sap could be discerned in any exterior part of the tree.

IT also appears, that the sap moves both in the substance of the ligneous circles, and in the veins by which they are separated : That, in both, it is in an ascending state : That it moves more expeditiously in these veins than in the circles themselves ; and that it moves more freely in young than in old circles, and, of course, more freely in the exterior than in the interior part of every trunk and every branch.

IT is asserted by Dr GREW †, and by Messrs BONNET ‡, LA BAISSÉ, and DU HAMEL, that, in the bleeding season, all the
sap

* *Physique des Arbres*, tom. i. p. 66.

† *Anatomy of Plants*, Lond. 1682. fol.

‡ BONNET sur l'Usage des Feuilles, p. 65.

sap is confined to the wood of the tree, and that no part of it moves between the wood and the bark. In many of the above experiments, I was convinced, that this opinion has arisen from some mistake. The flow of the sap, between the wood and bark, was daily and evidently perceived; likewise, that it was there always in an ascending state; and that it even moved more freely, and with greater rapidity, in this channel, than in any part of the substance of the wood.

§ 4.

THE cause of the ascent of the sap in trees, is a curious and important point in the history of vegetation, but still involved in obscurity. Many opinions have been formed on the subject, but these only at random, or, at best, only from a general view of vegetation. The cause still remains secret; nor is it likely that it will ever be brought to light, but by means of minute and accurate experiments.

THE ascent of the sap has been ascribed, by some, to fermentation*, and, by others, to a certain force communicated to it from the root; but without any evidence to shew, that such causes even exist.

THE ascent of the sap by filtration was an opinion rather more plausible; but it is opposed by some of the principal phenomena. Did the sap ascend like water in a sponge, or in capillary tubes, why should its motions be affected, nay even almost entirely regulated by heat and cold? Or why, as has been found in these experiments, should its motion be accelerated by placing a branch in an inverted position?

FROM Dr HALE'S experiments, it has been concluded, that the perspiration of the leaves is the great agent in the motion and elevation of the sap. But, from the experiments here related, it is evident, that the sap ascends with great vigour in trees, even when they are destitute of leaves.

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* HENCKEL. Flora Saturnizans, cap. 4.

THE ascent of the sap was ascribed by LUDWIG*, to the expansion of the air with which it is impregnated; and, with more reason, by others, to the expansion of the air contained in the *tracheæ*, or air-vessels of the plant. As these vessels exist only in the wood, and as it is by the wood chiefly that the ascending sap is conveyed, this, no doubt, forms a presumption, that they contribute, in some degree, to the elevation of the sap. But, as we have found, that the sap moves with more force upwards than in any other direction; and that, in certain circumstances, it is made to flow and ascend by cold as well as by heat, the expansion of air cannot, therefore, be admitted, in any shape whatever, as the cause of its ascent.

THE above experiments leave us still in the dark, as to the precise cause of the ascent of the sap. They shew, indeed, upon many occasions, that heat is the prime agent in producing this effect; and that, probably, by the expansion of the sap itself, rather than of any air, either contained in it, or in the *tracheæ*. The incisions upon the birch ran freely in the day-time, especially during sunshine, but dried up regularly, as the cold of the evening advanced. With a few exceptions, we find the ascent of the sap constantly promoted by heat, but retarded and even arrested by cold: Yet the precise manner in which heat and cold produce these effects does not appear. It is likely that there are other causes which co-operate. These probably are lodged in the structure of the plant, and to discover them, would require a more minute examination of that structure, than has as yet been bestowed upon it.

§ 5.

FROM the preceding experiments, we may now attempt a solution of that curious question in vegetation, why the terminating buds of branches are the first which disclose themselves in the spring? This phenomenon has been often imagined, and particularly

* LUDWIG Institutiones Regni vegetabilis, Lips. 1757, 8vo. p. 183.

particularly by M. BONNET *, to be a conclusive argument, in favour of a circulation of the sap. It is supposed, that the sap rises from the root, by the wood of a tree, to the extremities of the branches, and that from thence it returns again by the bark to the root, in a circulatory manner. It is therefore concluded, that the bud which terminates a branch must be the first that breaks in the spring, because it receives the first visit of this returning sap. The above experiments, however, enable us to account for this curious appearance in a different manner.

WE have had frequent opportunities to remark, that the sap moves with greater rapidity, and in greater plenty, in young than in old wood.

THAT inverted branches, in which the sap flows more copiously, than in those which are erect, do bud the soonest.

THAT young trees bud more early than those which are old ; and that the sap runs longer in young than in old wood.

ALL which facts evidently lead to this conclusion, That, as the buds towards the extremities of branches are placed upon the youngest wood, where they receive the most copious flow of the sap, they must, for this reason, swell more early, and disclose themselves sooner than such as are situated upon older wood. From the early breaking of the terminating buds upon branches, no proof can, therefore, be deduced in favour of a supposed circulation.

§ 6.

THE subtle and ingenious theory of the generation of plants, given by LINNÆUS †, which is countenanced by many excellent facts, is further confirmed by these experiments ; which strongly insinuate, that the tree is rather destined to support the pith, than the pith the tree ; the pith, according to that theory, being essentially necessary, not so much for the vegetation of the plant, as the formation of the seeds.

IN

* BONNET, p. 285.

† LINNÆI *Generatio ambigena*, Amœn. Acad. vol. 6.

IN our experiments, no sap could, at any time, be discerned either to ascend or descend by the pith. It is a substance quite unqualified for this purpose. It contains no lymphatics; and, so far as I know, none of the peculiar sap-vessels of any tree are ever situated in the pith*; a singularity which is not to be found in any of the other parts of a plant.

THE substance of the pith very much resembles that of the cellular texture of plants, but is, notwithstanding, of a very different nature†. The cellular texture freely imbibes and transmits water; but the substance of the pith obstinately repels it. I have often seen coloured liquors rise in the bark and wood of trees, especially in the wood of the elder, but not a particle was admitted by the pith, though a substance, to appearance, much better adapted for imbibing a fluid. All these circumstances lead to suspect, that the pith has little or no share in supporting the wood, the bark, or the general vegetation of the tree, and that its principal use is to aid the formation of the fruit.

ACCORDINGLY, in the numerous sections of trunks and branches made in the foregoing experiments, the buds were constantly observed to be connected with, and, in a manner, rooted, in the pith, by means of the *diametral insertions*‡. It may also be every where observed, that no bud exists upon any tree, without a connection with the pith; and that buds are always in greater abundance where the pith is most copious.

IT is supposed by LINNÆUS§, that the pith draws the nourishment from the bark; but the argument he uses in support of this position does, by no means, prove it. On the contrary, it rather appears from our experiments, that the pith must draw its nourishment from the wood; because, during the whole
spring

* M. DU HAMEL imagines, that there are in the pith both *vaisseaux propres*, and *lymphatiques*.

† M. DU HAMEL thinks, that the pith and the *tissu cellulaire* are the same substance.

‡ THE radiated lines of wood, which extend from the pith to the bark.

§ Amœn. Acad. vol. 6. p. 325.

spring season, the wood was replete with sap, while the bark was dry. Besides, when the trunk of a tree, for a certain space, is decorticated quite round, the pith, in the decorticated part, lives, and all the parts of the tree above it, so long as the wood continues green, and conveys sap, which it will do for years. The wood appears to be the great source of nourishment to all the parts of the tree. It is probable, that, from this alone, the pith is nourished, and that its communication with the bark is not to draw nourishment from it, but to afford some important aid to the growth of the buds.

§ 7.

THE important conjecture of Dr HALES, mentioned in the introduction to this paper, and on which he thought the truth or falsehood of the doctrine of a circulation chiefly depended, has been, in the course of these experiments, completely verified.

WE have found, that, in the early spring, the sap first begins to move at the bottom of a tree, and proceeds gradually upwards through all its parts: That the lower bark is first moistened, by a sap ascending from the root, and not by a sap descending from the branches, which was generally supposed. And further, that, from the first movement of the sap in the spring, till the time of vernalion, no descending sap whatever can be discerned in the tree.

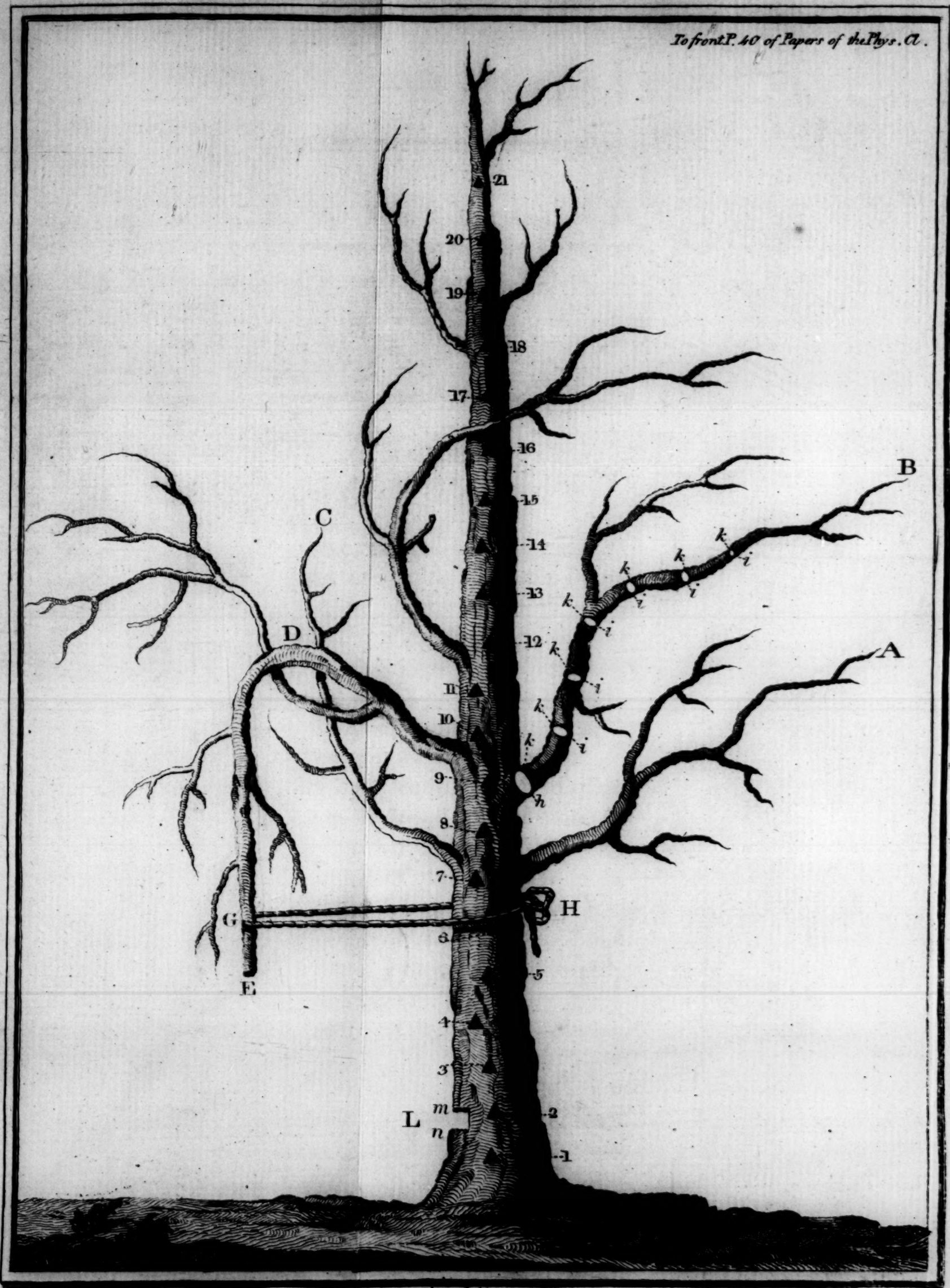
THESE, indeed, are important points against the doctrine of a circulation, but I do not think that they completely disprove it. They only prove, that there is no circulating sap in a tree during a certain season of the year, that is, from the time the tree begins to bleed till the appearance of the leaves. To decide the matter finally, it is necessary, that the route of the sap should also be traced, by accurate experiments, from the time the leaves first appear, till the defoliation of the tree in autumn. What the result of such an enquiry might be, I cannot determine:

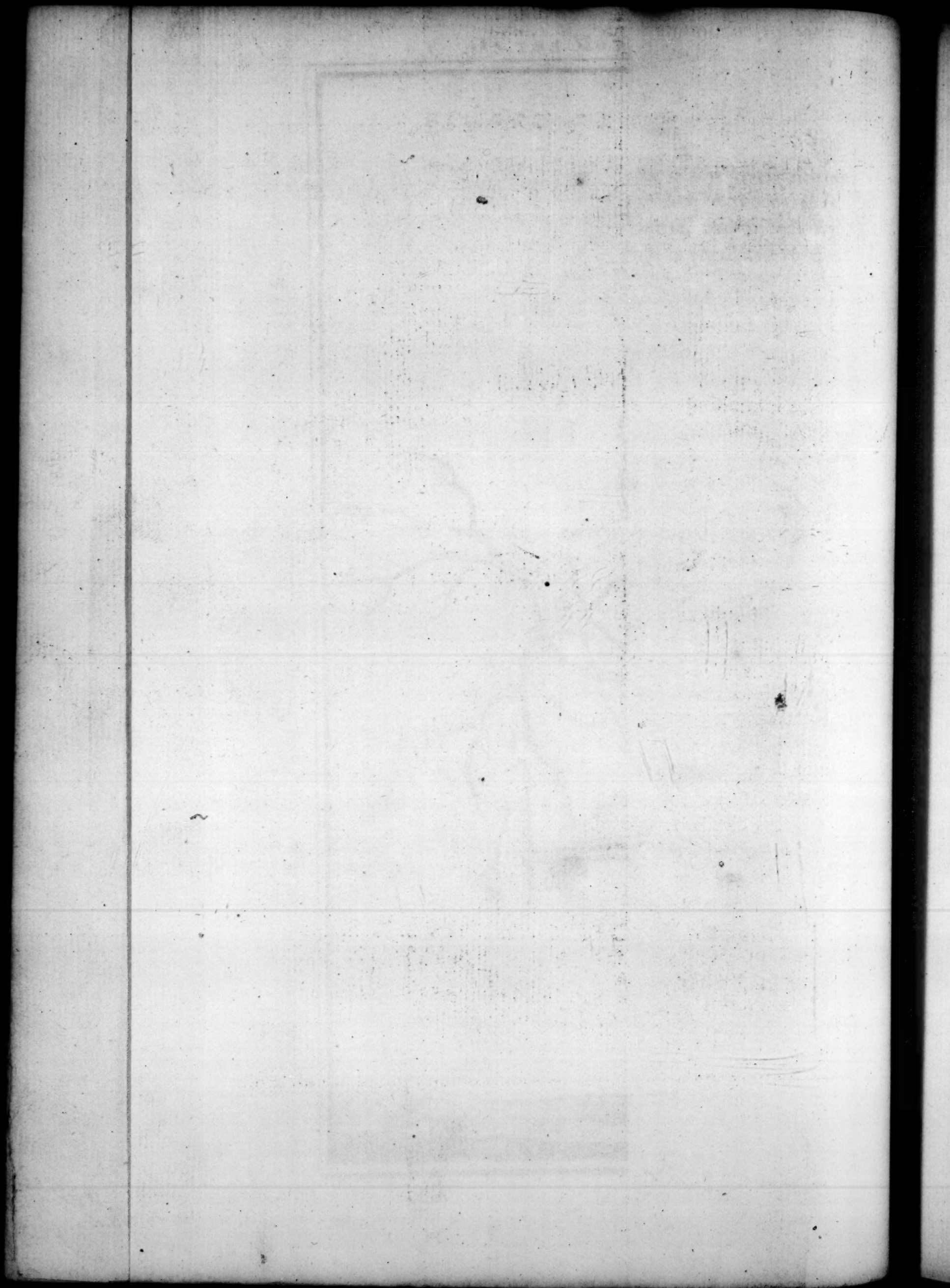
mine: And I shall only observe, that, from a few trials made with this view, I have been led to suspect, that, while a tree is in leaf, its sap observes a very different course, and moves by laws very different from those, by which it is regulated in the bleeding season.

mine: And shall only observe, that, from a few trials made with this view, I have been led to suspect, that, while a tree is in leaf, its sap observes a very different course, and moves by laws very different from those, by which it is regulated in the bleeding season.

ON THE MOTION OF THE SAP IN TREES.

To front P. 40 of Papers of the Phys. Cl.





II. *The THEORY of RAIN.* By JAMES HUTTON, M. D.
F. R. S. EDIN. and Member of the ROYAL ACADEMY of
AGRICULTURE at PARIS.

P A R T I.

*Investigation of the Law of Nature, on which is to be founded a
Theory of Rain.*

[Read by the Author, Feb. 2. 1784.]

THERE is an atmospherical appearance which is not explained by the known laws of heat and cold. It is the breath of animals becoming visible, in being expired into an atmosphere which is cold or moist; and the transformation of transparent steam into the state of mist, when mixed with air which is of a colder temperature. Natural philosophers have certainly considered these appearances as being explained in the general law by which heat and cold are communicated among contiguous bodies, otherwise they would have endeavoured to point out this particular law, which seems to depart from a more general rule, or does not follow the natural course of things observed on other occasions. The subject of this paper is to investigate a certain rule which, in the case now mentioned, may be discovered as directing the action and effects of heat and cold; and to form a theory of rain upon that investigated rule, concerning the evaporation and condensation of water.

THE air, inspired by an animal, may be considered as a menstruum dissolving water upon the warm and humid surface of the lungs, and as thus becoming saturated with humidity in this degree of heat. When this solution is again cooled, then,

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according to the known laws of condensation, water must be separated from the menstruum, and become visible by reflecting light. In like manner, water may be rendered an invisible elastic fluid, by means of heat alone; and this fluid, in being cooled, will be condensed into water, and appear visible. But it is now to be shown, that, when breath or steam becomes visible, in mixing with the atmosphere, this effect is not produced in consequence of the general principles of heat and cold: That, for the explanation of this appearance, there is required the knowledge of a particular law; and that the effects of heat or cold, in relation to air and vapour, proceed not always in ratios which are equally increasing or diminishing.

IN order to determine the actual ratio of the dissolving power of air, in relation to water in different degrees of heat, or the ratio in which the power of heat converts fluid water into elastic steam, we must consider the several ratios in which this operation may proceed; for if, among all the conceivable ways of proceeding, there shall be but one with which natural appearances shall correspond, it will then be reasonable to conclude, that this corresponding ratio is the particular law of nature, and that appearances of this kind are thus to be explained.

THE dissolving power of air, in relation to water, may be supposed to diminish as heat is increased; but this would be inconsistent with natural appearances in general. Such a supposition, therefore, would be now superfluous. This power might also be conceived as not affected with the increase or diminution of the degree of heat; and this supposition is agreeable to the solution of sea-salt in water: But, as it is certainly not the case with air and vapour, neither is this supposition to be made. The general rule of dissolving and evaporating bodies, is to increase with heat. This is now to be admitted as the case with water evaporating in air, or when, by means of heat alone, it is converted into steam; and it is only the ratio or measure of this operation which here is to be made the subject of consideration.

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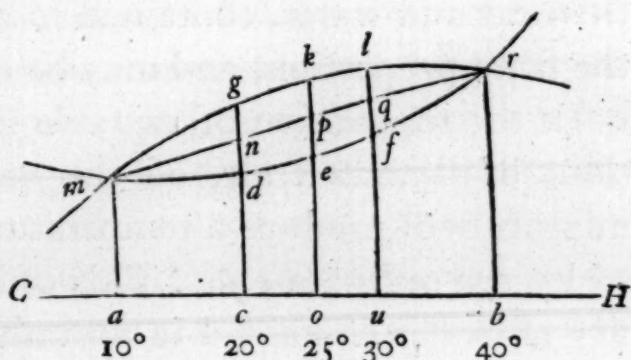
THERE are just three different ratios, in which this operation of heat on water may be conceived as proceeding.

1. THE solution may vary at the same rate with the heat, so that equal increments of heat shall be accompanied by equal increments of dissolved vapour.

2. It may vary at a greater rate, so that while the heat increases by equal differences, the quantity of dissolved vapour shall increase by differences which are continually augmenting.

3. It may vary at a less rate than the heat, so that while the heat increases by equal differences, the quantity of dissolved vapour shall increase by differences which are continually diminishing.

THESE three rates of evaporation, or solution of water in air, may be represented geometrically, thus: Let the straight line CH represent the scale of the thermometer.



Let the perpendicular ordinates, am , br , be taken in the proportion of the quantity of water, which can be held in solution, by a given quantity of air, of the temperatures a and b . Draw the straight line mr . Draw also the curve $mdefr$, having its convexity turned towards CH ; and the curve $mgklr$, having its concavity turned towards CH . It is evident, that the ordinates to the line mr will mark the progress of heat, and also of a solution, varying at the same rate with the heat. In like manner, the ordinates to the curve $mdefr$, will mark the progress of solution, varying at a greater rate than the heat; and the ordinates to the curve $mgklr$, will mark the progress of solution, varying at a less rate than the heat: For these ordinates are taken in the proportion of the quantity of water dissolved in

air, of the different temperatures, indicated by the points of the line CH , from which they are drawn.

LET us now consider these three rates of aqueous solution, with a view to know the effect of mixing together saturated portions of the atmosphere of different temperatures. For this purpose, let it be observed, that the ordinates to the line mr , drawn from the point of CH , which denotes the temperature of the mixture, will always represent the quantity of water contained (whether dissolved or not) in an unit of the mixture; for the ordinates ma , rb , were taken in the proportion of the quantities contained in an unit of air of the temperatures a and b ; and it is to be presumed, that, upon mixture, the heat, and also the water, are uniformly dissolved; and, therefore, both the heat and water, contained in an unit of the mixture, vary in the same proportion, and may be expressed by the same measure.

IN the supposition of equable solution, let us mix equal portions of saturated air, of the temperatures 10. and 40. the mixture will produce a temperature 25. which will be represented by the ordinate op . This ordinate also represents the quantity of water contained in an unit of the mixture. But it also represents (in the present supposition) the quantity of water, held in solution by an unit of air of the temperature 25.

INSTEAD of equal portions, let two parts of a saturated solution, of the temperature 40. be mixed with one part of a saturated solution, of the temperature 10. the temperature produced will be 30. and will be expressed by uq ; which will also express both the water contained in an unit of the mixture, and the quantity of water held in solution by the unit.

IN like manner, two parts of the temperature 10. mixed with one part of the temperature 40. produces a mean temperature 20.; and the ordinate cn expresses the heat, mixture, and solution of the unit.

EVERY mixture, therefore, that can be made of this solution will be found equally saturated, as are its constituent parts, and will

will have neither excess nor deficiency of the dissolved substance. This, however, is not the case in the other two rates of solution; for, as in those two cases the ordinates of heat and solution are not the same, the medium of heat will not express a solution saturated with humidity, or a mixture in which there is not superfluity of the dissolved substance. Let us now consider these more particularly.

IN the curve $m d e f r$, which represents the increasing rate of solution, let equal portions of the solution in 40. and in 10. be mixed, then the medium of heat in 25. will have for the ordinate of mixture, that is to say, the quantity of water contained in this mixture $o p$, whilst $o e$ is the ordinate of solution, that is to say, the quantity of water that may be dissolved in this degree of heat, consequently, $e p$ is the quantity of water that cannot be retained in solution, in this medium temperature produced by the mixture.

IF two parts of the solution in 40. be mixed with one of that in 10. the medium temperature will be 30.; and, if two parts of the last be mixed with one of the other, the medium temperature produced will be 20. In those two cases, $f q$ and $d n$ are the quantities which will be separated from the solution.

IN like manner, may be found the effect of any mixture of two portions in different temperatures, and the quantity of water that would be separated on these occasions ascertained, if the actual curve of evaporation were known, or that rate in which the solution of water in air proceeded.

THE progress of solution, instead of being in an increasing rate, may be in one that decreases, in relation to the progress of heat. In that case, the mixture of two portions of the solution in different degrees of heat, instead of producing a separation of superfluous moisture in the medium temperature, by reason of the supersaturation, as in the former case, will be followed by an increased power for the evaporation of water, by having an undersaturation in the mixed mass.

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THIS proposition will be illustrated in the curve $mgklr$, which represents the decreasing rate of solution. Let equal portions in 40. and 10. be mixed, and let the ordinate be raised in the medium degree of heat 25. ok will then be the whole power of solution, or the quantity of water that air is capable of dissolving in this degree of heat; but op is the quantity of water that is actually in this mixture; consequently, the air is here undersaturated with humidity by the quantity pk .

IF two parts of 40. shall be mixed with one in 10. or two of 10. with one in 40. the quantities of undersaturation will be changed, and ql and ng will express those quantities, in relation to the mixtures in the medium temperatures.

THUS, in every mixture of solution in this decreasing rate of solution, there will be found an undersaturation of the air, with regard to the dissolved moisture, instead of a supersaturation, which is found in all the mixtures of the solution in the increasing rate.

LET us recapitulate:

IF the solution of water in air increases with heat in an equal rate, no mixture can be made of portions, in different degrees of heat, that will produce either super or undersaturation; but the mixture, like the constituent portions, will be always saturated without superfluity.

IF the solution of water in air increases with heat in a decreasing rate, the mixture of two saturated portions, in different degrees of heat, will produce no condensation of humidity, but, on the contrary, will be capable of dissolving more aqueous substance.

IF, on the other hand, the solution of water in air increases with heat in an increasing rate, the mixture of two saturated portions, in different degrees of heat, will produce a condensation of humidity, as being supersaturated in the medium temperature of heat.

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THIS last case properly applies to the phænomena of breath and steam, which have been rendered visible, in mixing with air that is colder than themselves ; and it explains the various appearances that may occur, in mixing together several portions of air, more or less saturated with humidity, and in different temperatures of heat and cold : For

It is not every mixture of the atmospheric fluid, in different temperatures, that should, according to the theory, form a visible condensation ; this effect requiring, in that atmosphere, a sufficient degree of saturation with humidity. Neither is it necessary, for this effect, that the two portions to be mixed should each be saturated with humidity up to the temperature in which it then is found ; it is sufficient, that the difference in the temperatures of those portions to be mixed should more than compensate the defect in point of saturation. But, if a mixture shall be made of two portions of the atmosphere, both fully saturated with humidity, then, however small may be the difference of their temperatures, there is reason to believe, that a condensation, proportionate to this difference, will take place.

HAVING thus explained the atmospherical appearance of visible mist, produced in the mixture of invisible fluids, we may now apply this rule of condensation as a principle for the theory of rain.

RAIN is the distillation of water, which had been first dissolved in the atmosphere, and then condensed from that state of vapour or solution. It is the explanation of this condensation that must form the theory of rain. So far, therefore, as the condensation of aqueous vapour has been explained, and so far as the evaporation of water from the surface of the globe is understood, we have a theory for the general appearance of rain.

WATER, indeed, is condensed in a cloud equally as in rain, and yet clouds may subsist without rain. But, it is evident, that, without condensation of aqueous vapour in the atmosphere, no rain could be produced ; and that, however different causes
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may influence water condensed in the atmosphere, and operate variously, in either retaining it longer in a suspended state, or bringing it sooner to the ground, the condensation of the water is properly the cause of rain. We may now endeavour to confirm this theory of rain, in having again recourse to natural appearances.

THE most convincing experiment, in confirmation of the theory, would be, to have rain or snow produced by a mixture of portions of the atmosphere, properly conditioned for the condensation of the contained vapour. But such an experiment as this we also have. M. DE MAUPERTUIS, in his *Discours sur la mesure de la terre*, says, That, at Tornea, upon the opening of a door, the external air immediately converts the warm vapour of the chamber into snow, which then appears in what he calls "de gros tourbillons blancs." A similar appearance happened at St Petersburg, *anno* 1773. I have it from Professor ROBISON, who saw it. It was in a crowded assembly, the company suffering from the closeness of the room, a gentleman broke a window for relief. The cold air rushing in, formed a visible circumgyration of a snowy substance.

THE law of nature, on which this theory of rain is founded, may be now considered in relation to its final cause; or how far it may appear to be conceived in wisdom for the purpose of this world, as affording a proper climate for plants and animals.

HAD the law, respecting aqueous evaporation in the atmosphere, been conceived in any other manner than that which has been now found established in nature, the summer's heat, which is the cause of vegetation, could never have been attended, as at present, with refreshing showers of rain. By the circulation of the fluid atmosphere, the heat of torrid regions is carried away, and the cold of frigid regions is brought to temperate the excessive heat that is excited upon the surface of the earth in the summer solstice; but, if no condensation of humidity in the atmosphere could be produced by the mixture of
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its parts, however saturated with aqueous vapour, and in different degrees of heat, the natural cold of the polar regions, and the contingent cold of snows, accumulated, during winter, upon the higher countries, however transported to warmer regions, would be altogether ineffectual for the purpose of forming clouds and condensing rain.

THE present system of the atmosphere is so calculated as that every mixture of different portions of that fluid, unequal in their degrees of heat, and saturated with humidity, must procure a condensation of water. This system, therefore, of the atmosphere, with this particular law in relation to heat and cold, is calculated to produce rain, by the continual mixture of its parts, which are in different temperatures.

IN this system, we shall see, that the cold regions of the polar circles are not useless and inactive in the operations of this world. In like manner, the frozen regions of the Alpine situations of the Continent, serve a purpose, in the constitution of this earth, by preserving, in the accumulated snows, a store of the winter cold for the summer season; and thus preparing cold portions of the atmosphere to be mixed with the warmer portions, saturated with humidity, and ready to produce rain*.

WHILE the atmosphere is thus tempered, by transporting the heat and cold of distant regions, the regions of the earth most distant from the sea, may be supplied with showers of rain at every season of the year, or at any season, according to the arrival of those streams of the atmosphere which are in the proper conditions for producing, by their mixture, a medium degree of heat, and a supersaturation or condensation of aqueous vapour. This wise system of things, or this useful purpose in the œconomy of the world, could not have been accomplished without that particular law of nature respecting aqueous condensation; for, if the mixing together of the atmospheric streams produced no condensation, the summer hemisphere of

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* THE explanation of this proposition depends upon Dr BLACK's theory of latent heat.

the globe would be parched with drought, and the winter hemisphere deluged with rain.

To see this, let us consider the summer hemisphere of the globe, warmed by the influence of the ascending sun. From the laws of hydrostatics, it will appear, that there should be formed, on this occasion, two opposite currents in the atmosphere above this half of the globe, the one moving along the surface of the earth, from the polar region towards the equator, the other flowing above, in a contrary direction. This circulation, therefore, being supposed, let us see what follows, according to the actual constitution of things. On the one hand, the evaporation of the winter's moisture from the surface of the continent, warmed by the summer sun, must tend to saturate with humidity the polar atmosphere, as it acquires an evaporating power from its increasing heat; on the other hand, the progress of the upper current, from the tropic towards the pole, in having its degree of heat diminished by the general cooling cause, will naturally bring the mass to a point of saturation with the aqueous vapour which it had received. In this state of things, the two opposite currents in the atmosphere, while separate, might pass on without condensing humidity sufficient to produce rain; but the moment that sufficient portions of those saturated streams shall mix, not only cloud, but showers will be produced; because the sudden formation of a mean degree of heat, in the mixture of two portions in different temperatures, must condense a quantity of vapour sufficient to form rain.

RAIN having fallen in a place, in consequence of the mixture in the atmosphere above, this will naturally be followed by clearness in the sky and sunshine, which is so necessary for warming the surface of the earth, and for giving health and vigour to growing plants.

BUT, without the particular law now investigated, respecting evaporation and condensation of vapour, neither rain nor dew could

could be produced upon the summer hemisphere of the globe, nor perhaps ever in tropical latitudes ; evaporation would every where take place, more or less ; the general tendency would be to saturate the atmosphere with water, or fill it with vapour in its greatest heat ; and the mixture of the different parts of the atmosphere would only conduce to temper the saturation, without producing any condensation of vapour in the mean degrees of heat. But when, in consequence of the declining sun, the influence of the general cooling cause should prevail, the atmosphere would gradually become clouded, and be darkened. This cloudiness would increase to a general distillation of the condensed vapour ; and this distillation would be uniformly continued, until the returning summer should change the state of condensation to that of evaporation.

SUCH a system as this, of six months rain and six months drought, constantly succeeding, would not have presented us with all that variety of beautiful objects which we now behold ; nor would it, like the present constitution of this world, appear calculated with all that wisdom of design which we may perceive to be in the possibility of things ; for such an uniform excess of cloud and condensation, on the one hand, and of sunshine and evaporation, on the other, would not appear to fulfil the intention of providing sustenance and satisfaction, as far as possible, for every living thing ; whereas, in the actual system, now under contemplation, while both the extremes of drought and of wetness are so wisely avoided, temperate drought and moisture, rain and sunshine, so beneficial to the œconomy of this world, are every where bestowed with the most provident attention, but not without a variety of different degrees ; which most evidently marks out perfection in the design, where such a multitude of different beings, dependent on the various temperament of those opposite elements, are to be provided with the necessary conditions for their life, for the maturity of the individual, and for the continuation of the race.

PART II.

*The Theory of Rain applied to natural Appearances.**[Read by the Author, April 12. 1784.]*

HAVING formed a theory of rain, founded upon a general law respecting the condensation of aqueous vapour contained in the air, it is now proposed to make some application of this theory to natural events, in considering the meteorological observations of the globe, and endeavouring, either to explain appearances that are not otherwise understood, or, from those appearances that are evident in themselves, to draw conclusions in confirmation of the theory.

UPON this occasion, where there is an indefinite variety in a series of particular observations, it is necessary to investigate some order in those events, and to form a generality among phænomena, which will then be physical truths, and may be compared with the theory.

1st, It may be required to show some reason why, on all the surface of the earth in general, there are always seasons of rain, whether regular or irregular. Here the subject of enquiry will properly respect the generality of rain.

2^{dly}, It will be proper to consider such regular periodical rains, as may be found with the circumstances attending their production, which then would serve to try the theory, or to illustrate it. Here the regularity of rain will be the object in view, and not its generality.

3^{dly}, It will be necessary to examine the apparent exceptions from the doctrine founded on the theory, or those appearances of irregularity in nature that do not flow from the theory, although they may be in perfect consistence with it, and might be explained, had we the peculiar circumstances which are the occasion

occasion of the event. Here, again, the subject to be discussed will be the apparent exception from the generality of rain.

4thly, THE proportional quantities of rain falling in the different situations of the earth may be made an object of our attention, in order to illustrate the theory, as well as to explain appearances. Here a comparative estimate will be made of climates in relation to rain.

5thly, and *lastly*, HAVING thus considered the particular appearances of the globe in general, so far as our imperfect knowledge of them reaches, we may next examine a particular place, such as is best known, in relation to the appearances in general of rain. The meteorological observations of our own climate will here be the proper object of examination, with a view to confirm the theory, and to form general rules, which may be occasionally applied, either to any particular meteorological register, or to every observation of change in our weather, that is, such as shall be attended with circumstances proper for judging of the principle.

1. *Of the Generality of Rain.*

LET us suppose the surface of this earth wholly covered with water, and that the sun were stationary, being always vertical in one place, then, from the laws of heat and rarefaction, there would be formed a circulation in the atmosphere, flowing from the dark and cold hemisphere to the heated and illuminated place, and returning above, from the heated place, in all directions, towards the place of greatest cold.

As there is, for the atmosphere of this earth, a constant cooling cause, this fluid body could only arrive at a certain degree of heat; and this would be regularly decreasing from the centre of illumination to the opposite point of the globe, most distant from the light and heat. Between those two regions of extreme heat and cold, there would, in every place, be found

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two streams of air, flowing in opposite directions. If those streams of air, therefore, shall be supposed as both sufficiently saturated with humidity, then, as they are of different temperatures, there would be formed a continual condensation of aqueous vapour, in some middle region of the atmosphere, by the commixtion of part of those two opposite streams.

HENCE there is reason to believe, that, in this supposed case, there would be formed, upon the surface of the globe, three different regions, the torrid region, the temperate, and the frigid. These three regions would continue stationary; and the operations of each would be continual. In the torrid region, nothing but evaporation and heat would take place; no cloud could be formed, because, in changing the transparency of the atmosphere to opacity, it would be heated immediately by the operation of light; and thus the condensed water would be again evaporated. But this power of the sun would have a termination; and it is there that would begin the region of temperate heat, and of continual rain. It is not probable, that this region of temperance would reach far beyond the region of light; and, in the hemisphere of darkness, there would be found a region of extreme cold and perfect dryness.

LET us now suppose the earth as turning on its axis, in the equinoctial situation. The torrid region would thus be changed into a zone, in which there would be night and day; consequently here would be much temperance, compared with the torrid region now considered; and here perhaps there would be formed periodical condensation and evaporation of humidity, corresponding to the seasons of night and day. As temperance would thus be introduced into the torrid extremity, so would the effect of this change be felt over all the globe, every part of which would be now illuminated, consequently heated in some degree. Thus we would have a line of great heat and evaporation, graduating each way into a point of great cold and congelation. Between these two extremes of heat and cold, there would

would be found, in each hemisphere, a region of much temperance, in relation to heat, but of much humidity in the atmosphere, perhaps of continual rain and condensation.

THE supposition now formed must appear extremely unfit for making this globe a habitable world, in every part; but, having thus seen the effect of night and day, in temperating the extremities of heat and cold in every place, we are now prepared to contemplate the effects of supposing this globe to revolve around the sun, with a certain inclination of its axis. By this beautiful contrivance, that comparatively uninhabitable globe is now divided into two hemispheres, each of which is thus provided with a summer and a winter season. But our present view is limited to the evaporation and condensation of humidity; and, in this contrivance of the seasons, there must appear an ample provision for those alternate operations in every part; for, as the place of the vertical sun is moved alternately from the one tropic to the other, heat and cold, the original causes of evaporation and condensation must be carried over all the globe, producing either annual seasons of rain, or diurnal seasons of condensation and evaporation, or both those seasons, more or less, that is, in some degree.

THE original cause of motion in the atmosphere is the influence of the sun heating the surface of the earth, exposed to that luminary. We have now supposed that surface to be of one uniform shape, and similar substance; from whence it has followed, that the annual progress of the sun, perhaps also the diurnal progress, would produce a regular condensation of rain in certain regions, and the evaporation of humidity in others; and this would have a regular progress in certain determined seasons, which would not vary. But nothing can be more distant from this supposition than is the natural constitution of the earth; for the globe is composed of sea and land, in no regular shape or mixture, while the surface of the land is also irregular, with respect to its elevations and depressions, and various,

ous, with regard to the humidity and dryness of that surface which is exposed to heat as the cause of evaporation. Hence a source of the most variable motions in the fluid atmosphere, always affected with the heat of each particular part of the surface with which it comes in contact; hence a tendency to saturate every part of the atmosphere with aqueous vapour, more or less, so far as other natural operations will admit; and hence a source of the most irregular commixture of the several parts of this elastic fluid, whether saturated or not with aqueous vapour.

ACCORDING to the theory, nothing is required for the production of rain besides the mixture of portions of the atmosphere, sufficiently saturated with humidity, and in different degrees of heat. But we have seen the causes of saturating every portion of the atmosphere with humidity, and of mixing the parts that are in different degrees of heat. Consequently, over all the surface of the globe, there should happen occasionally rain and evaporation, more or less; and also, in every place, those vicissitudes should be observed to take place, with some tendency to regularity, which, however, may be so disturbed as to be hardly distinguishable upon many occasions. Variable winds, and variable rains, should be found in proportion as each place is situated in an irregular mixture of land and water; whereas regular winds should be found in proportion to the uniformity of the surface; and regular rains, in proportion to the regular changes of those winds, by which the mixture of the atmosphere necessary to rain may be produced. But, as it will be acknowledged, that this is the case in almost all this earth, where rain appears according to the conditions here specified, the theory is thus found to be in conformity with nature, and natural appearances are thus explained by the theory.

2. *Of the Regularities of Rain.*

THE variable rains and falls of snow, which happen irregularly in most places, having been explained from the natural constitution of this globe, from the proper disposition of its solid and its fluid parts, and from the periodical influence of heat and cold, occasioned by the motion and position of this globe, in relation to the sun, we shall find it easy to understand the more regular periodical appearances, with regard to rain, which happen in a few places of the earth.

IN looking for a regular periodical cause for the mixture of portions of the atmosphere, in different degrees of heat, and sufficiently saturated with humidity, nothing appears so promising as the trade-winds in the Indian sea, blowing one half of the year in one direction, and, during the other half, in a contrary direction; for, as these streams of atmosphere are limited, they must somewhere produce a mixture of different portions of that fluid mass; and, in finding rain to be the consequence of these regulated events, or as corresponding to these probable causes, we shall have reason to conclude, that those mixed portions of the atmosphere have been sufficiently saturated with humidity, and in different temperatures, in relation to heat. But this is actually the case; we find, in this place, regular appearances, with regard to rain, which correspond to the regular causes now assigned, for the commixtion of the atmosphere. This correspondence, therefore, while it explains those natural appearances, confirms the theory.

THE islands which are placed under the line, in the middle of the Indian ocean, seem to form for themselves conditions of periodical condensation, that correspond to the diurnal influence of the sun, and to the nocturnal motions in the atmosphere. It is not here pretended to explain, *a priori*, how, in such places, either always, or at certain seasons, there should be daily periods of rain. It is enough to find that such is the fact, and that

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it can be explained by no other theory but this, in which we find a diurnal cause of mixing together the different parts of the atmosphere, by means of heating the mountains, and surface of the earth, by the great illumination of the sun, thus rarefying some parts of the atmosphere, and producing commotions in the fluid mass of air which surrounds the island.

THESE periodical commotions in the atmosphere of islands in tropical situations must not be considered as a thing doubtful in its nature, or a matter merely conjectural. The fact is well ascertained in the sea and land breezes that are felt regularly blowing every day in those opposite directions. This is the fact; and that rain should accompany these commotions follows from the theory provisionally; that is, in case of the proper conditions for the condensation of vapour being found in the atmosphere thus mixed. Now, these conditions are not always found where we find the breezes. But, in the islands now under consideration, situated under the line, and in a sea that must be hotter than any other upon the globe; a sea, either confined constantly between the tropics, or continually supplied from the tropical region of the Pacific ocean, it is not unreasonable to suppose that sufficient saturation with aqueous vapour may be found in the atmosphere; nor that, in the diurnal commotions of this fluid, there may be portions of it mixed in different degrees of heat.

It is, in like manner, that the periodical rains which happen regularly upon the different coasts of the peninsula of India must be explained. The regular monsoons in those seas occasion the transportation of air, saturated with aqueous vapour, which has flowed along the surface of the sea, here to be elevated and mixed with those portions which, having lost their heat to a sufficient degree, are in a condition to produce, by their commixture, a condensation of water upon the land. Nothing can better illustrate this explanation than the great annual and periodical rains which happen upon this continent, and which are exhibited

hibited upon so large a scale, that it is almost impossible to have them explained in any other manner. Let us examine those circumstances which cannot be mistaken, and which may be sufficient for deciding in this question.

FROM the east to the west of this great tropical continent of Asia and Africa, the rivers inform us, that it rains in the season of the summer solstice; and that, on the contrary, fair weather is here produced by the removal of the heating cause. We cannot suppose, that heat is an immediate cause for the condensation of aqueous vapour; nor can we suppose that this effect should not be produced by cold; for this would be no less than to suppose in nature an inconsistency, which never has appeared. While, therefore, we allow the laws of nature to be steady, the effect of the summer sun, in this continental situation, must be, to elevate the heated air, and to have its place supplied by that which has come, fraught with aqueous vapour, from the neighbouring seas: But being arrived here, upon this heated continent, this humid air must be elevated into the higher regions of the atmosphere, and either be transported from thence towards the polar regions, there to be gradually condensed, as the cooling cause takes place, or it must here fall in rain, by finding a cause for its condensation. Upon the first supposition, no rain should be found here during the summer season; or the rivers, by which we are to judge of this event, should be at the lowest after summer. But, as the opposite of this is true, the rivers being then in their swelled state, it necessarily follows, that the humid atmosphere, transported from the sea, must have its water condensed upon this heated continent in the summer solstice; and there is not, at present, any other principle known, by which this operation might take place, or any other theory by which those natural appearances of periodical rain might be explained.

THE summer sun, which proves a cause of rain in certain regions, where seas, affording great evaporation from their heat,

are in the neighbourhood, proves, on the contrary, a cause of drought in other regions, where the source of water, or evaporation, is more scanty, or at a distance. A winter continent, heated by the elevation of the summer sun, should be more disposed to have drought than rain, during the period of its heat, unless some transient streams of atmosphere, proper for the purpose, should reach this place, and happen to meet: There would thus be occasioned showers of rain, of great importance to the vegetation of the place, but not to be considered as a general season of rain.

BUT the case is altered, upon the declining of the summer sun. The atmosphere, upon this continent, then becoming either saturated to its degree of heat, or cooled to its degree of saturation, is disposed to produce rain, with every mixture which is in a different temperature. Hence a source of autumnal rains and winter snows, which may fall with all the regularity of the tropical rains; and of this we also have information, from the regular covering of those northern continental regions, with a permanent snow; an event that happens with great constancy, and may be considered as a regular periodical rain.

HAVING thus found rain as being properly caused, upon two opposite principles, a vertical or highly elevated sun, and the removal of that cause of heat, no place should be found, upon the surface of this earth, where rain may not happen, more or less, from the one or other of those causes. But there are places where it is said never to rain: And now the question is, how far these appearances may be consistent with the theory of general rain which has been given.

3. *Of apparent Exceptions from the Generality of Rain.*

THE argument for the generality of rain has been founded upon these two principles, *first*, That mixed portions of the atmosphere are, by means of a certain law of nature, qualified
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for the production of rain; and, 2dly, That there is, in the constitution of this terraqueous globe, causes for mixing the different parts of the atmosphere, particularly, during summer, or by the influence of the sun. Had the rule, established by nature, for the evaporation of water and condensation of vapour, followed any other ratio than that which has been investigated in the theory, no mixture of the atmosphere could have produced either mist or rain, and the regions of condensation must have been limited to the regions of cold, where, in all probability, there must have been continual rain, with no other variation, perhaps, than a little change in the limits of the condensing regions, each of these two regions increasing and diminishing alternately, with the seasons of winter and summer.

IN the actual system of the globe, the case is different, and there is ample provision made, in general, for rain; but, in the theory which has been given with regard to a certain part of that system, there is required, for the production of rain, certain circumstances and conditions which do not flow immediately from the heating and cooling causes exerted every where upon the globe. If those conditions, therefore, are not observed in certain places, no rain should there appear, notwithstanding the nature and situation of such places should be similar to those of other places where abundant rain is found. But, if it be reasonable to conclude, that, in some particular situations, there should not be found the proper conditions for mixing together portions of the atmosphere, sufficiently saturated with humidity, and in different degrees of heat, or that these should occur but seldom, then, in finding upon the whole earth precisely such a spot or two, in which seldom or very rarely it is found to rain, we might be allowed to suppose a failure in the conditions proper for rain in those places; and to conclude this from the effect, where it is not possible to see farther into the cause.

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THE lower Egypt, and a narrow spot upon the coast of Peru, are the only examples that we have of this singular occurrence. It would have been impossible, *a priori*, to have concluded, that, of all the places upon the earth, these two should have been those in which rain should not happen; the knowledge of man, in tracing future effects from known causes, will ever be, perhaps, too imperfect for such an undertaking, where it is necessary, not only to value every condition necessary in the data, but also every quantity and degree in those different conditions; but, though we may not form that judgment *a priori*, yet, finding that these are the only places in which rain does not fall, we may be allowed to conclude, that such is the natural state of the winds about those places, as to prevent the proper conditions for producing rain.

This conclusion is also, in some measure, confirmed from ULLOA's observations with regard to the wind, which appears to blow so steadily upon the coast of Peru, that either continual rain might be here expected, or no rain at all, upon this coast. In this last case, we would have reason to conclude, that the vapours from the sea were carried over the coast to be condensed, by mixing with other streams of cold atmosphere in the mountainous regions of the Andes, where it rains so abundantly for most part of the year.

IF, on the one hand, we suppose the wind blowing continually from the sea, without mixing with a stream of air proper to condense humidity, it must pass over this heated coast, without letting fall a drop of rain. If, on the other hand, we shall suppose the trade-wind, which has come over the Atlantic, to be continued over the ridge of the Andes, westward, after having deposited much rain in this hilly region, there would be also no reason to suppose, that this current of atmosphere, passing over the heated coast, should there find conditions proper for condensing its humidity.

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BUT the question is not, if, in any situation upon the surface of the earth, a judgment might be formed, *a priori*, of no rain happening, during a certain course of time, which to us seems endless; the contrary is the result of reasoning from the theory of aqueous condensation, and from the natural constitution of the globe. But here are two little spots upon the earth where it almost never rains, contrary to a conclusion of a generality in the phenomenon of rain. It must, however, be considered, that this generality was not a thing absolute in the conclusion, and necessary in the universal of the case. It was only absolutely necessary in some places; and it was, from the indefinite variety of case, in all probability, most general. But this generality will admit of such an exception as may be consistent with the theory.

Now it is nowise inconsistent with the theory to suppose, that there should be, upon the globe, a few places, in which the concurrence of the various conditions necessary for producing rain should not be found: That the greater part of the earth should be found without rain, would certainly be inconsistent with the theory; but that a particular spot or two, containing no diversity of climate or of country, no variation of mountain and of valley, should be found without rain, instead of transgressing the necessary conclusion of a generality with regard to rain, confirms the theory, in presuming the necessity for the concurrence of certain circumstances or conditions, which are required in order to condense humidity in air.

THE cause of rain, though often exerted, will not be always sufficient to produce the full effect; for a scanty condensation of aqueous vapour will not descend in rain, but remain suspended in a visible form, and thus produce mist upon the surface of the earth, and clouds in the atmosphere above. There are also some situations in which the effect of the summer sun is, to form a certain haze, that diminishes very much
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the intensity of heat which the direct rays of that luminary would produce.

THUS there are an indefinite variety of appearances to be produced from this simple principle of aqueous condensation; for, in taking the gradation from the one extreme of transparent atmosphere to the other of the densest cloud, and from the falling of the gentlest mist and dew to the heaviest rain, hail and snow, we have an indefinite variety of appearances, all flowing from one simple principle.

4. *Comparative Estimate of Climates in relation to Rain.*

IT has been now observed, that the places in which it seldom or never rains are, in a manner, as nothing, and ought only to be considered, upon the globe, as a point or two, where rain, so variable in its quantity, appears to cease. Here, therefore, may be considered as placed the least quantity; and from this to the greatest quantity, there is a considerable latitude, and an indefinite gradation.

IT will be necessary to reduce these particular observations to a generality, and thus to have some facts to which the theory may be applicable. But, in order to have the theory tried by those appearances, it will be necessary to state the principles upon which, according to the theory, the differences in the quantity of rain in each place should depend. We may thus form some general principles, by which the natural appearances, with regard to the quantities of rain, may be compared.

IN each place of the earth, the general quantity of rain depends upon two separate principles, which may be variously compounded. The first principle upon which the formation of rain depends, according to the theory, being the mixture of different streams of the atmosphere, the quantity of rain must depend, in the first place, upon circumstances favourable to this mixture, or this meeting of different winds.

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THE meeting together of different streams of air is not sufficient for the production of rain; it is also required, that those streams of air be in degrees of heat sufficiently different to produce a proper condensation; but as every place, except the poles themselves, may be considered as situated between two different regions, the one hotter and the other colder than itself, any place in which circumstances are found favourable for the commixtion of different winds, may be considered as having also this condition favourable for the condensation of rain; and thus these two conditions, the mixture of winds, and the proper temperatures of those winds, may be comprehended under this first principle.

THE second principle to be now considered, is the quantity of humidity contained in the streams of air which are mixed for the production of rain. Here is a distinct principle, which is perfectly different from the first; and, according to the theory, the quantity of rain in any place, *cæteris paribus*, will necessarily depend upon this principle. There being thus two different principles for determining the quantity of rain, we must always have an eye to each of those principles, in comparing natural appearances with the theory. With this view, it will be proper to consider separately these two principles as the cause of rain; and it will be easy to understand the compounded effect of both, after ascertaining what share of operation may belong to each.

WERE the surface of this globe uniform, or a perfect spherical form, whether of sea or land, it does not appear how there should be produced any wind, or streams of air, but what were regular, in being determined by the influence of the sun and motion of the earth, by which the different parts of that surface would come variously, but regularly, to be affected by the influence of this luminary. But the surface of this globe is composed of sea and land; and this diversification is various and irregular. Here is, therefore, a source of variable winds,

or different streams of air, which may mix for the production of rain. The surface of the earth is also diversified with plains and mountains, woods and barren deserts; and here is fixed another source of variation; first, for the various heating of that surface; secondly, for the production and mixture of different streams of air; and, lastly, for the influencing or determining the quantities of rain in each place.

MOUNTAINS, in general, may be considered as conducing much to the mixing of different streams of air; for, by the heating of the sides of those mountains, more directly exposed to the rays of the sun, there are necessarily formed partial streams, or occasional currents, in that fluid mass of atmosphere; and these currents must tend to mix its different parts. Mountains, also, in opposing the more general streams or currents of the atmosphere, must deflect those currents in their course, and form a source for the meeting together of currents coming from the different sides of those ridges, and from the opposite quarters of the same side. Therefore, mountains and their neighbourhood may be considered as being, *cæteris paribus*, more favourable to the production of rain than plains and low countries little above the level of the sea. But, as this conclusion is found, in general, to be verified from experience, the theory here receives fresh confirmation from natural appearances.

THUS, it will appear, that the effects commonly ascribed to mountains, *viz.* breaking the clouds by their mechanical operation, and attracting them by their electric quality, and such like operations, are erroneous, or unnecessary for explaining the general appearance of mountainous situations having more rain and thunder than the plains. Neither is the cold, natural to the tops of mountains, to be considered as productive of rain, in cooling and condensing the atmosphere; for the cold upon the top of a mountain is the effect of the atmosphere; this

this place being no colder, in general, than any other in the neighbouring atmosphere at the same height.

ACCORDING to this principle, there should be more rain upon the land than upon the sea, which, being a plane, and homogeneous in its nature, has neither the same power to produce streams of air, nor to mix together those which it may produce. We find this also consistent with experience. There is less rain, in general, upon the sea than upon the land, so far as we may judge from all that we know. In the constant trade-winds, there is very little rain; but, in the variable winds adjoining to the trade-winds, rain falls in abundance, which is strictly agreeable to the theory. So certain also is this general principle, that the most experienced seamen and best observers have made the remark, that, in those great oceans, the appearance of a cloud at a distance was an indication of an island, which they seldom failed to find from that indication.

THE second principle in the cause of rain is the different degrees of humidity that may happen to be in the streams of air which are mixed. Here we shall also find a great source of variation as to the quantity of rain to be produced in equal circumstances, *i. e.* with a perfect similitude in the other requisite conditions. It is not, however, so easy to exemplify the reality of this principle from actual observation, as it is with regard to the other, which had been so evident as to have been received into a general opinion. We shall, therefore, be obliged to look out for some appearances, by which the theory may be confirmed, in proving the two following general propositions:

1st, THAT the place where the greatest quantity of rain should fall, *ceteris paribus*, is in the land contiguous to a great sea in a tropical situation.

2^{dly}, THAT the place where the least quantity of rain should fall upon the earth, *ceteris paribus*, is the most inland part of the continent of Europe and Asia, in a cool or temperate latitude.

IF these two propositions be true, the theory, so far as depends upon this principle of condensation, will be confirmed. It is, therefore, now proposed to give an example in each of those propositions, from the comparison of which examples with the observations made in other places, we may arrive at the truth, and find the propositions proved.

THE first of these is with regard to the greatest quantity of rain. Nobody will doubt of the East Indies being a place properly corresponding to the terms of the proposition; and it has been found, that 104 inches of rain have there fallen in one place in a season; which is at least three times the quantity which generally falls in the regions subject to our observations.

WITH regard to the second case, I know of no meteorological register to consult, by which the comparative dryness of the region, specified in the proposition, might be determined; but there are some notorious facts from which this conclusion may be formed, by taking a proper compass in our reasoning.

THE Caspian sea, so far as it remains stationary, in neither increasing nor diminishing, affords a measure of the evaporation from the surface of that sea, in relation to the rain that falls upon the country, which is drained by the rivers running into it; conversely, it affords a measure of the quantity of that rain, in relation to this evaporation. But this country is in the very place which we would observe, with respect to the quantity of rain, as being near the centre of the greatest continent. If, therefore, we could find a similar example in a different situation of the globe, we should then, in making a comparison, find data for drawing some conclusion concerning the quantities of rain which fall upon those different places. The lakes in North America will afford this comparison. The medium latitude of these lakes is about 45° .; and this is nearly that of the Caspian sea; consequently, *cæteris paribus*, there should be, in those instances, an equal evaporation from equal surfaces.

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WE may next compare the two extents of land which supply with water those two compared evaporating surfaces. If, in those two cases, the surfaces of land, collecting rain, be equally proportioned to the surfaces from which that water is to be evaporated; and, if we shall suppose, that the quantity of rain which falls upon those two surfaces of land, is equal in proportion to their spaces; in that case, we should conclude, that all the water received into those lakes might be evaporated, as it is in the Caspian sea. If, on the contrary, an immense quantity of water issues annually from those lakes, while there is reason to conclude, from the comparison of the Caspian, that all the received water should be evaporated, we shall then have reason to conclude, that there falls much more rain upon this inland place of North America, than upon a similar situation in the great continent of Europe and Asia. The fact is, that the Caspian receives its water from a surface of land, larger, in proportion, than that from whence the lakes of America are supplied; consequently, there should no water issue from the lakes, but all evaporate, according to this rule.

IN this calculation, the evaporation has been supposed to be equal, from equal spaces, on the surface of the Caspian and the lakes. But it may be alleged, that the evaporation from the lakes may be less than that from the Caspian; consequently, there might appear to be a redundancy of water, in this case, from the lakes, although the proportion of rain might be no greater. This argument, upon another occasion, might be conclusive; but, in this case, where a greater power of evaporating water must attend the lesser quantity of condensed vapour, as flowing necessarily from the same cause, *viz.* the great distance from the sea, to allege a greater evaporating power upon the surface of the Caspian than on that of the lakes, is evidently to give up the argument; unless the greater evaporation shall be supposed to arise from a different cause; and here the only cause of
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this kind that occurs is a greater degree of heat; which may be now considered.

THERE is no doubt that there would appear to be less heat in the climate of North America than in that of Europe, comparing equal latitudes; but, unless this greater cold arises from some other cause than that which produces the greater quantity of condensed vapour, this argument from the temperatures, in relation to heat and cold, would be no more conclusive than that from the dryness of the climate. Now, it must be evident, that, upon a continent where there is a greater quantity of condensed vapour, there must be more clouds to intercept the heat of the sun, or its influence in heating the surface of the earth; and also, there must be more of that heat lost, in relation to our sensation, by being employed in evaporating the greater humidity from the surface of that earth. The proper conclusion is, that the greater cold, in the climate of North America, compared with the climate of the Caspian, arises from the same cause which produces the greater quantity of rain; at least, that this is the case in a great measure, and that we have no rule for valuing the effect of any other cause.

HAVING thus found, that a greater quantity of rain falls upon a given surface in the smaller continent of the new world, than upon a similar one in the greater continent of the old, the theory is so far confirmed; as, according to this theory, there should be found more favourable circumstances, or conditions, for the condensation of aqueous vapour in the atmosphere, and the production of rain in the smaller than in the greater continent.

5. *The Theory applied to Meteorological Observations.*

HAVING compared the general appearances of the globe, in relation to rain, with the theory, and having found that perfect correspondency betwixt them, which is necessarily required in physical truths, we may now consider the general appearances of
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of a particular place upon the globe, such as the island which we inhabit. Because, having the opportunity of making meteorological observations for this place, we ought to find, in those observations, a certain confirmation of the theory, if it is just; and we should also be able to form a certain explanation of those natural appearances, so far as the theory shall be admitted.

IN such an island as this of Great Britain, situated in a region of variable winds and temperate heat, more or less influenced, on the one side, with the most extensive continent of the earth; on the other, with the Atlantic ocean, there is reason to conclude, that showers will often happen, without extreme quantities of rain falling at any one time; and that the climate of this country, with respect to drought and moisture, will incline towards the latter. This is also found to be the case, comparing Britain with the drier regions of the continent. But what is most interesting at present, will be to observe what are the concomitant circumstances of those frequent showers which fall in this variable climate; for here the best opportunity may be afforded of having the doctrine confirmed, in finding the conditions required in the theory for the observed effect.

BEFORE entering on this subject, where latent causes are to be concluded from observed effects, it will be necessary to mention some circumstances which, from the nature of things, render these observations of phenomena less conclusive, on many particular occasions, although nowise deficient, on the whole, for ascertaining truth, if properly considered.

IN considering the meteorological observations of this country, with a view to illustrate and confirm the theory, three things occur, as requiring separate attention: 1st, The motion of the wind, or the quarter from whence it comes. 2^{dly}, The degree of heat, or indication of the thermometer placed in the atmosphere. Last^{ly}, The changed weight of the atmosphere, or indication of the barometer. These three variable things are.

are to be considered in relation to the perceived effects, rain or drought, which are supposed to happen in consequence of one or more of those three causes ; that thus we may endeavour to discover which of these is to be esteemed the proper cause, and which to be considered as only a concomitant appearance.

NOTHING appears to us so distinct as the motion and direction of the wind, yet nothing is so fallacious as the reasoning from this appearance, considered as a cause in the changes to be produced in the atmosphere, and as explaining those effects of change which we perceive. In making our observations on the wind, we are limited to a spot, which may be considered as a point in the line of the wind's direction ; and, from our observations in this spot, we are apt to conclude with regard to operations which include a great extent. When, for example, the wind blows from the west, in our observation, we say, it has come along the Atlantic ; when, from the east, that it has come from the continent of Europe ; yet, unless we suppose the wind, in moving, to preserve a straight line, or direct course, it must be evident, that, in those two cases, the wind, instead of coming, as we imagine, from the east or west, may truly have come from the north or south. Now, to any one who considers attentively the nature of motions in the fluid atmosphere, it must appear, that a straight line is that, of all others, which there is the least reason to conclude should take place in the variable winds of the globe ; but these are the winds only with which we are now concerned.

It will likewise be evident how great a difference there is between a west or east wind and a south wind, on the one hand, or a north wind, on the other. Now, what a confusion, in our reasoning, must sometimes follow this presumption of our principles ? For, if we may confound a south wind, in our observations, with a wind coming to us directly from the west, we must also be subject to mistake a north wind upon a like occasion, *i. e.* in taking it for a west wind. Thus, therefore, in reasoning

reasoning from our observations, a south wind and a north wind, things as different in their qualities as opposite in their directions, will sometimes be confounded.

THE practical observation to be now made from this is, that we should always allow the appearance, with regard to the direction of the wind, or place from whence it came, to be corrected by those concerning the temperature of this fluid, in relation to heat and cold, so far as there is reason to conclude that this indication of the thermometer is a thing of greater certainty than that of the wind's direction.

THERMOMETRICAL observations, with regard to the temperature of the atmosphere, are, from their nature, variable. The surface of this earth is heated by the influence of the sun; and the atmosphere, in contact with this surface, is heated by communication of temperature: Or, in like manner, it is cooled, upon another occasion, when it happens to be warmer than the surface of the earth. But, whatever may be the temperature of the atmosphere, there is, in general, a certain allowance to be made for the diurnal influence of the sun; and this is found out, by experience, both with regard to its quantity upon the scale of the thermometer, and to the time of its periodical appearance in the rotation of the earth.

HAVING thus learned to make allowance for the diurnal variation of the thermometer, its variable temperature, as an indication in our meteorological journal, is next to be considered, and the causes of that change. It must be evident, that nothing can contribute so much to change the temperature of the atmosphere, as change in the direction of the wind, supposing, that, in our observation, it gives no false indication. It is impossible, that the southern atmosphere should be transported over this island, without giving heat above the mean temperature of the season at which the observation is made; or that the wind should come directly from the north, without producing the opposite effect. Therefore, we are obliged to establish this

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principle, that whatever degree of heat or cold is felt exceeding the mean temperature, or that which is proper to the season of the observation, must be attributed to the motion of the atmosphere from the south or north, although the direction of the wind, upon the little spot of our observation, may have given another indication.

THE atmosphere moving from the eastern or western regions is not necessarily either warmer or colder than the place of our observation; but it may be occasionally either the one or the other; and, from the known nature and circumstances of such places, there are also rules to be formed for judging of these occurrences. It would, however, be foreign to our present view to enquire into these rules; and it is only necessary to observe, upon the whole, that there is no steady cause for either heat or cold, in general, being transported to us, in the case of the atmosphere being moved directly from the east or west.

HENCE will appear the truth of that general rule which was proposed for judging of the region from whence the atmospheric stream has moved to us, *viz.* that we should ascribe more to the heat and cold of that fluid, compared with our mean temperature for the season, than to the direction in which the stream passes over our head. The observations which relate to the barometer may now be considered.

THE barometer is as just a measure of the weight or compression of our atmosphere, as is the thermometer of its degree of heat or cold. But natural philosophers, observing the connection of changes in the barometer, with the disposition of the atmosphere to rain, have judged, that one of those things stood in relation of a cause to the other; and, finding, that often the mercury in the barometer fell from its stationary place before the change from fair to rainy weather, they have concluded, that rarity in the atmosphere was an immediate cause of rain. If such a conclusion as this could be admitted upon sound principles, the theory now given, with regard to the phænomenon of rain,

rain, would be useless or uncertain; but, that supposition with regard to the effect of rarity in the atmosphere, so far from being supported by the truth of observation, or from physical principles, is destitute of every confirmation.

WHATEVER shall be supposed the cause of rain, one thing is evident, that the necessary consequence of the falling of rain from the atmosphere is to make that atmosphere more light, proportionally to the quantity of water which, after being separated from the air, is supported by the earth on which it falls. But there do not fall such quantities of rain in these regions, as to explain the quantity of lost pressure, indicated by the barometer upon these occasions; therefore we are obliged to reject the consideration of the appearance of the barometer, either as the cause or the effect of rain; although, inasmuch as they are connected with the causes of rain, the indications of the barometer are found, from experience, to be of some use in the prognostication of that event.

THOSE great changes in the atmosphere, which occasion the remarkable risings and fallings of the barometer, are not partial, as happening to a narrow spot around the place of observation, but are of great extent. This appears from the comparison of different registers; for, at the distance of 400 miles, and perhaps much more, two barometers proceed nearly in the same manner, rising and falling, in general, almost in the same ratio; but, within that distance, rainy weather often happens in one place, while it is fair weather in another; consequently, in supposing either the levity of the atmosphere, or its gravity, to occasion rain, we should be led into absurdity, by concluding the same cause as producing contrary effects, or a cause existing without its proper effect.

INSTEAD of supposing the changed compression of the atmosphere to be an immediate cause of rain, let us suppose this change to be the consequence of some great emotion produced in that fluid body; then, as different parts of the atmosphere

come naturally to be mixed on those occasions of intestine motion, we should have, according to the theory, an immediate cause somewhere, in all probability, for the condensation of humidity, or production of rain. It does not, however, appear why the falling barometer should indicate rain any more than the rise of the mercury; at the same time, it may be made to appear how, in general, the gradual rise of the barometer, to its greatest ordinary height, and its continuation in this growing state, should naturally indicate fair weather, or much fair weather, in the quarter of the globe concerned with those observations.

IN order to perceive this, let us suppose such fair weather to take place, and that there is an undisturbed atmosphere in this quarter of the earth; then it will appear, that the necessary evaporation from the surface of the globe must gradually increase the weight of the atmosphere, or its height, or both. But, in this case, the mercury in the barometer must rise with a gradual progress, while there is no motion in this quarter of the atmosphere, sufficient to cause a general rain, or to make a change in this natural state of the barometer. Thus, though, perhaps, there is not any condition of the barometer that positively indicates rain, we have, from the observations of that instrument, a positive indication of fair weather.

BUT, though this indication of fair weather be positive in its nature, as being founded on principle, and not on supposition; yet it is only true conditionally; that is, providing no other cause interferes, or that the stationary place of the mercury be not occasioned by the contrary operation of different changes. This deceitful occurrence, however, though often happening in small degrees, will rarely prevail to such an extent as might render doubtful, in general, the positive indication of the barometer, in relation to fair weather.

HAVING thus obtained a positive indication of what may be called the fair-weather seasons, and the rainy seasons, requiring com-
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motions of the atmosphere, which may naturally occasion the mercury to fall, we shall, in this manner, have explained the indications of the barometer, so far as connected with the cause of rain : At the same time, it is not pretended to explain, upon this principle, why the falling of the barometer should, in general, be a necessary indication of rain, any more than the sudden rising of the mercury in that instrument.

IN the temperate regions of the earth, there are great changes of the barometer, compared with those which happen in the torrid region between the tropics, where they are but small. This also should be the case, according to the nature of things ; that is to say, in considering heat and cold, upon the surface of the earth, as the causes of motion in the portions of the atmosphere which come more immediately within the compass of our observations. The torrid region, however greatly affected by the diurnal motion of the earth, or influence of the sun, is but little affected by the annual progress, which, to all the rest of the earth, from the 40th degree of latitude, is so extremely interesting. This region of perpetual summer, having, on each side, a temperate region, can never have the tranquillity of its atmosphere molested with extreme rarefaction and condensation, like the temperate zone, bounded, on the one side, with this torrid region, and, on the other, with a region that experiences such an extreme vicissitude in its temperature. The changes from summer to winter, and from winter to summer, necessarily produce great motions in the atmosphere ; but it is only in the atmosphere of the temperate regions that the effect of those motions is felt upon the barometer.

THE tranquillity of the barometer, in the equinoctial situation, does not arise from the want of a moving cause to actuate the atmosphere in that region ; for there the sun, which may be considered as the prime mover of the machine, is at all times powerful. But this tranquillity arises from defect in the joint conspiring

spiring together of all those causes, which, in the temperate zone, excite to so great changes in the pressure of the impending atmosphere. This moving cause in the equinoctial region is more equable than it is any where else, except perhaps at the poles; and it is always exerted nearly in the same direction, in forming a motion from east to west. When it is otherwise, that is, when some casual change interrupts the equable progression of the atmosphere, the most violent effects may appear, in particular places, for a short space of time, without much change in the general quantity of the atmosphere in this region, by which the station of the mercury in the barometer is determined; consequently, the barometer, which is much affected by the motions of the atmosphere in the temperate regions, should be but little affected with those motions in the middle region.

To conclude, the barometer is an instrument necessarily connected with motions in the atmosphere; but it is not equally affected with every motion in that fluid body. The barometer is chiefly affected by those motions by which there are produced accumulations and abstractions of this fluid, in places or regions of sufficient extent to affect the pressure of the atmosphere upon the surface of the earth. But as every commotion in the atmosphere may, under proper conditions, be a cause for rain, and as the want of commotion in the atmosphere is naturally a cause of fair weather, this instrument may be made of great importance for the purpose of meteorological observations, although not in the certain and more simple manner in which it has been, with the increase of science, so successfully applied to the measuring of heights.

HAVING thus established this principle, that the barometer is but little affected with the fall of rain, we may now employ some general observations of this instrument, to discover or illustrate certain operations in the atmosphere, which are more immediately connected with the cause of rain in the region now considered.

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It is found, that, in the tropical or equinoctial region, the variation of the barometer is small, compared with that in the temperate zone, notwithstanding there may be greater falls of rain in the first than in the last. But, if the power for evaporating water, and of condensing vapour, increases in a higher ratio than the equable progress of heat and cold, it must appear, that, to produce the same quantity of aqueous condensation in a hot region, in which the atmosphere is saturated with vapour, a smaller quantity of the atmosphere, of different temperatures, to be mixed for that purpose, will be required; and, conversely, a greater quantity of the atmospheric streams must concur for producing the same quantity of rain in the temperate regions, not equally saturated with vapour; consequently, greater temporary accumulations and local abstractions of the atmosphere, in the one region than in the other. Hence, a greater rise and fall of the barometer, accompanying the changes of the weather, in relation to rain and drought in the temperate than in the tropical region.

Thus, certain natural appearances, which are perfectly inconsistent with the levity of the atmosphere being the immediate cause of rain, find an easy explanation in the present theory, which requires the mixture of several portions of the atmosphere in different temperatures of heat. We may now proceed to consider the natural appearances which generally attend rain in this island, with a view to recommend the theory, in showing that such mixtures actually take place.

1. If the mixing together of different streams of the atmosphere be the cause of rain, calmness, or steady breezes, should be the attendants of fair weather; but this, in general, is the case. The converse of this is also true; for partial showers never happen without wind, although general rains, or such as are produced in the higher regions of the atmosphere, may be attended with a calm, or fall without disturbance, in the place of our observation. Now, the truth of the proposition is manifested

fested in this, that, by people who reason from the immediate observation alone, wind is attributed to the shower as an effect, when it may more truly be considered as standing in the relation of a cause.

2. WHEN, in calm weather, rain begins, it is reasonable to expect that this should be followed by wind; and, in like manner, if in windy weather it begins to rain, it may be reasonable to expect that the wind should calm, after a certain period, with the rain. These undoubtedly are the general appearances; and these appearances are explained upon this principle, that wind is the cause of rain, and that, in the opposition of winds, a calm may be produced.

3. DURING a calm and clear sky, showers never happen; but, with squalls of wind, sudden showers appear. In calm weather, before it rains, the heaven is all overclouded, and the rain becomes general, equable, and not in spots: But, when attended with wind, the rain is unsteady; one while, the spot around us is involved in the thickest cloud and heavy rain; another while, it is under the clearest sky; and these alternate operations in the atmosphere of thickening and clearing continue during the squally weather.

4. THESE facts are from my own observation; and they necessarily imply the mixture of hot and cold streams of air for the production of rain. But sometimes this operation is a thing visible in itself; for when, by means of the motion of the clouds, the atmosphere is perceived to be moved in opposite directions, here, it is evident, nothing is required besides the proper conditions, in those mixing streams, for the condensation of rain. Now, I have had it from experienced seamen, men of great knowledge and observation, that, in our channel, they had often occasion to remark this opposition in the winds, or the clouds going against the wind, as being a sure mark of heavy rain to follow.

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5. THE changes in the temperature of our atmosphere attend the alterations of rain and fair weather, no less evidently than those changes happen, in consequence of changes in the streams of wind. If the wind has blown from the southern and warmer regions, replete with humidity, it brings warm weather, and this may continue to be fair; but, when rain succeeds, it is generally found, that a change of wind succeeds the rain, and then the air becomes more cold. In like manner, if a cold north wind prevails, it may continue fair; but, when rain succeeds, there is commonly a change in the wind, and also in the temperature of the atmosphere. And, in general, as many alterations as shall happen in the prevalencies of those different winds, or streams of hot and cold atmosphere, so many repetitions have we of the rain.

UPON the coast of Hudson's bay, while the thermometer is at 90° . with calmness and a sky perfectly serene, it is common for a sudden gust of wind to come from the north-west, with such violence as to threaten oversetting every thing; and along with the blast, there comes a shower of snow or hail. This lasts only a very short space of time; it clears up, grows calm and serene, as before; but the temperature of the air has much changed; from 90° . the thermometer will fall to 50° . for a short space of time, and then it gradually rises to the ordinary heat. This observation, which I have from my friend Mr GRÆME, a gentleman of great accuracy, who lived long in that country, points out clearly the agitation of the atmosphere as being the cause of rain, and not its consequence. It also demonstrates the sudden mixture, in the atmosphere, of air which, for the season, is extremely cold, compared with the general temperature of the atmosphere upon this continent.

BUT, in the application of these general rules to particular cases of observation, it must always be considered, that though intestine commotion, or mixture of the atmosphere, be necessarily required in order to produce rain, it is not every mixture

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or commotion in the atmosphere that will be followed by this effect ; for though mixture of the atmosphere be a necessary condition in the cause of rain, it is not the only condition ; and, therefore, the same appearances, in relation to the winds, and to the different temperatures of the atmosphere, may be observed, while rain, as the effect, may either follow or not, according as the third condition may or may not take place : That is, that the mixed atmosphere be sufficiently saturated with vapour or humidity ; which is a thing that cannot perhaps be made the subject of our observation.

6. RAIN happens in the hottest weather, and in every degree of temperature, down to the freezing point ; it requires, therefore, much attention to observe the changes of temperature in the atmosphere that usually attend the production of rain, in all this range of the thermometer from 80° . to 32° . But, about the freezing point, the effects of heat and cold are so manifest, in the fluidity and congelation of water, that a person can hardly avoid making observations which will tend to confirm the theory.

WHEN, after settled frost, it begins to snow, the cold is always found to relent, and the thermometer to rise to the freezing point, or nearly, however low it may have been before. But after the snow has fallen, and the sky becomes clear, the cold increases, until it again resumes its former intensity, or even proceeds to a greater degree. This is an appearance which is easily explained in the theory ; and it is an appearance which every person, who can make an observation, has it frequently in his power to verify.

7. THE climate which we inhabit has, for character, temperance in extreme ; our winters and our summers differ but little from each other in their mean temperatures. There is, in this island, but little steady determination for the wind, which, in general, is extremely variable. The variable nature of our winds cannot be the effect of the temperance of our climate ;
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but the temperance of our climate may, in some measure, be produced in consequence of the variable nature of our winds. So far as this is the case, that the mixture of different streams of the atmosphere temperates the heat and cold of our air, this operation should be attended with proportionate condensation of aqueous vapour. Here the theory is brought to the test of observation. But, before deciding the point in question, let us understand what it is which, in observation, should be decisive with respect to the theory.

It is not the quantity of rain which falls during the year, nor in any portion of it, that affords a principle by which to form a judgment in relation to the present question; for it is the continuance of rain, and not the quantity, that is the object of enquiry. The number of days and hours, throughout the year, in which it rains, is, no doubt, a proper subject for our observation, in order to form an estimate with regard to the point in question; but it is not itself that point in question. The point is the condensation of aqueous vapour in the atmosphere; and though no rain can fall without the condensation of aqueous vapour, there may be much condensation of that vapour, without rain, as a testimony of that event. Thus we are led to direct our observation to other phenomena besides rain; appearances which may be equally conclusive, in relation to the point to be decided, with rain itself. Now, these appearances, in which the condensation of aqueous vapour is equally demonstrated with that of rain, are no other than cloudiness in our atmosphere.

THE question respecting the theory being now brought to this issue, with regard to observation, it may be demanded, what is the proportion of serene sky and cloudiness in the atmosphere that properly belongs to this climate? Here is a question proposed, that requires not extreme exactness in its answer. I believe every body, from their recollection, will allow, that, for one day or hour of clear sunshine, there are two or three of

cloudiness in the atmosphere ; and this is sufficient for determining the question, whether or not the condensation of aqueous vapour be prevalent in the climate of this island ?

8. CLOUDINESS in the sky being a demonstration of aqueous condensation in the atmosphere, in like manner as is the case with rain, this appearance may now be examined with regard to the temperature of the air, in relation to heat and cold, that commonly attends on this occasion. Let us begin with summer ; and suppose the weather to be warm ; that is, precisely in the natural temperature of the season. There is no question with regard to the effect of a clear sky, or continued sunshine : Heat is certainly the effect of sunshine ; and this heat is accumulated in the earth, *cæteris paribus*, in proportion to the intensity of the light and the duration of the illumination. The question now to be examined is this, what should be the effect of condensation of aqueous vapour in the atmosphere at this season, and in this summer temperature ; that is to say, whether should heat or cold be the consequence of this operation ?

NOTHING is so easy as the answer to this question. We suppose the atmosphere in the mean temperature of the summer-season, and that a condensation of aqueous vapour is produced by the admixture of a current of atmosphere in a different temperature. Now, as this effect may be produced by the admixture of air, either hotter or colder than our atmosphere, which is supposed to be quite serene, the effect must be a change of the temperature of our atmosphere, either to a greater or a less degree of heat than its mean temperature for the season, according as the supervening atmosphere, producing cloudiness in our sky, shall be either hotter or colder, in its temperature, than that in which we had been involved immediately before.

FROM this conclusion, we will now draw a practical observation, which may be of some utility in trying the theory and explaining appearances. If the heat of the atmosphere be,

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at any time, above its mean temperature for the season, and a change shall happen from a serene sky to cloudiness, we have reason to expect, that the extreme heat will be tempered, and the atmosphere consequently cooled. But, if the temperature of our atmosphere be below its mean heat for the season, then, from the change of clearness for a cloudy sky, we have reason to look for a change from cold to hot.

FROM this also we have a proper explanation of a general appearance, with regard to the serenity of the sky, in every climate, and in the opposite seasons of summer and winter; for this serene sky, or clear atmosphere, is perfectly consistent with the two extremities of temperature; that is, with that of heat, upon the one hand, and of cold, upon the other. It is only a mixture of those two extremes, that is to say, of hot and cold atmosphere, which produces, at the same time, cloudiness to the sight, and temperance in relation to the sense of heat and cold. Thus will be explained a common observation, with regard to the weather of this country, that the air is always cold, below its mean temperature for the season, when the sky is clear. The country people allege that it is then frost, even in the midst of summer. They probably find hoar-frost early in the morning, especially in the higher parts of the country; and surely the making of ice in Bengal justifies that observation.

9. THE formation of hail is evidently upon the same principle as that of snow. The one is, therefore, equally with the other, explained by the theory. There are, however, peculiarities in the production of hail, which do not take place in that of snow; but these peculiar circumstances are to us, perhaps, unknown; and as there is nothing in the appearance of hail that is, in any respect, inconsistent with the theory, the confounding of snow and hail brings no error into our science, nor affects the doctrine with the least uncertainty. Hail is evidently formed by the collection of smaller molecules, which ultimately are of the
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nature of snow ; and it is probably by means of electrical attraction, that this collection is performed.

10. THERE is one appearance more, that often attends rain, and, therefore, should be considered ; this is thunder, which so frequently accompanies violent and sudden rain. But, as we are ignorant of any principle upon which electricity should be the cause of condensing aqueous vapour in the atmosphere, this is not the place for examining what may be the effects of electricity, with regard to aqueous vapour condensed from its elastic state, farther than that it is most reasonable, and also consistent with appearances, to suppose a more sudden attraction of the condensed particles of water, than what happens upon other occasions, where even a degree of electrical repulsion may preserve them from immediate contact, and protract the fall of rain, by suspending the condensed vapour in form of mist.

III. *On the CAUSES which affect the ACCURACY of BAROMETRICAL MEASUREMENTS.* By JOHN PLAYFAIR, A. M. F. R. S. EDIN. and Professor of Mathematics in the University of EDINBURGH.

[Read by the Author, March 1. 1784. and Jan. 10. 1785.]

THOUGH the labours of M. DE LUC, and of the excellent observers who followed him, have brought the barometrical measurement of heights to very great exactness, they have not yet given to it the utmost perfection it can attain. Some causes of inaccuracy are still involved in it; of which we ought, at least, to estimate the effects, if we cannot correct them altogether. The allowance made on account of the temperature of the air, implies in it a hypothesis that has not been examined, nor even expressed; and many other circumstances that affect the density of the atmosphere, have either been wholly omitted, or improperly introduced. The object of the present paper is to correct the errors that arise from these causes, or, where that cannot be done, to assign the limits within which those errors are contained.

I. THE most important correction introduced by M. DE LUC, is that which depends on the temperature of the air. His observations led him to conclude, that, at a certain temperature, marked nearly by $69^{\circ}\frac{1}{4}$ of FAHRENHEIT, the difference of the logarithms of the heights of the mercury in the barometer, at the upper and the lower stations, gave the height of the former of those stations above the latter in 1000ths of a French toise; but that at every other temperature above or below $69^{\circ}\frac{1}{4}$, a correction of .00223 of the whole was to be added or subtracted

subtracted for every degree of the thermometer. By observations still more accurate, it has been found, that the temperature at which the difference of the logarithms gives the height in English fathoms, is 32° ; and that the correction at other temperatures is .00243 of that difference, for every degree of the thermometer*. The manner of estimating the temperature of the air, adopted in all these observations, was the same; an arithmetical mean was taken between the heights of the thermometers, at the upper and lower stations, and was supposed to be uniformly diffused through the column of air intercepted between them. M. DE LUC, however, was sensible that this supposition was inaccurate; and General ROY, too, has observed, that “one of the chief causes of error in barometrical computations proceeds from the mode of estimating the temperature of the column of air from that of its extremities, which must be faulty in proportion as the height and difference of temperature are great†.” It will appear, however, that this estimation, though adopted merely on account of its simplicity, and probably on no other principle than the general one of taking a mean between two observations, which, taken singly, are inaccurate, comes nearer to the truth than there was any reason to expect.

2. It is certain, that the atmosphere does not derive its heat from the immediate action of the solar rays. These rays, in traversing that subtle and transparent medium, are but slightly refracted, and, meeting with little obstruction, neither lose nor communicate much of their influence. We are assured of this by many experiments; and we know, that air, in the focus of a burning glass, is never heated till some solid body be introduced.

* General ROY makes the fixed temperature 32° , and the expansion for 1° , = .00245, at a medium. Sir G. SHUCKBURGH makes the fixed temperature $31^{\circ}\frac{1}{4}$, and the expansion, as here assigned, viz. .00243. *Phil. Transf.* 1777. It is sufficient for us at present to know these numbers nearly. According to the formula laid down hereafter, they will all require to be corrected.

† *Phil. Transf.* 1777.

roduced. The atmosphere, therefore, is warmed by the earth, from the surface of which a quantity of heat is continually flowing off, and ascending through the different strata of the air into the regions of vacuity, or of æther. But this ascent, on the whole, is uniform; because there is a certain temperature which, though varied by periodical vicissitudes, remains under every parallel the same, as to its mean quantity. Every stratum, therefore, of the atmosphere, whatever be its height, gives out, at a medium, the same quantity of heat that it receives; in other words, its mean temperature is constant, and neither increases nor decreases, on the whole.

3. LET there be three strata, then, of the atmosphere of the same thickness $\dot{x}$, and contiguous to one another; so that, if x be the distance of the first from the surface of the earth, that of the second may be $x + \dot{x}$, and of the third $x + 2\dot{x}$. Let b, b', b'' , be the heats of the strata, and $\Delta, \Delta', \Delta''$, their densities respectively: Then, since the quantity of heat, communicated in an instant from one stratum of a fluid to a contiguous stratum, must be, as the difference of their temperatures, multiplied into the density of the colder, and divided by the density of the warmer, the heat communicated, in an instant, from the first stratum to the second, $= (b - b') \frac{\Delta'}{\Delta}$; and that communicated by the second to the third, $= (b' - b'') \frac{\Delta''}{\Delta'}$. But, since the difference of Δ and Δ'' is indefinitely small, as also that of Δ' and Δ'' , we have $\frac{\Delta'}{\Delta} = 1$, and $\frac{\Delta''}{\Delta'} = 1$; so that the heat gained by the middle stratum is $= b - b'$, and that lost by it $= b' - b''$. Now, these two quantities must be equal, in order that the temperature of the stratum may remain uniform, that is, $b - b' = b' - b''$; or, in other words, the heat of the first stratum exceeds the heat of the second, as much as the heat of the second exceeds the heat of the third. Therefore, the heat of the successive strata must decrease, by equal differences, as we ascend through equal

M spaces,

spaces, into the atmosphere; and, in general, the differences of temperature must be proportional to the differences of elevation.

It is to be understood, however, that this law is subject to certain anomalies, both annual and diurnal, and those intermixed with other accidental irregularities, which it would be difficult, perhaps impossible, to ascertain. All that can be said of it is, that it is the law which nature tends to observe, and that the sum of the deviations from it, on the one side, is probably equal to the sum of those on the other. In an effect that is perpetually subject to the action of accidental and unknown causes, the discovery of a mean, from which the departures on the opposite sides are equal, is all that we can reasonably expect; and it is sufficient for us to know, that, though any particular conclusion may involve an error, yet, if a multitude of instances be taken, the errors will certainly correct one another.

4. If, therefore, H be the heat at the surface of the earth, and b the heat at any given height a , above the surface, the heat, at any other height, as x , will be $H - \frac{(H-b)x}{a}$. At a medium, it is found, that FAHRENHEIT's thermometer falls a degree for every 300 feet that we ascend into the atmosphere; so that, if x is expressed in fathoms, the heat, at that height, is $= H - \frac{x}{50}$.

5. BUT though we are thus led to conclude, that the decrease of heat in the superior strata of the atmosphere is proportional to their elevation, there is no reason to suppose, that the condensation produced by that decrease is also uniform. Indeed, the experiments of General ROY have placed it beyond all doubt, that the variations in bulk of a given quantity of air are, by no means, proportional to its variations of temperature. Those experiments, though very numerous, are too few to ascertain exactly

exactly the law which connects these variations, and we must have recourse to reasoning, in order to supply this defect. Let us suppose that air of a given temperature, for instance, of 32° , by the loss of one degree of heat, is contracted $\frac{1}{411}$ or the part m of its whole bulk; its bulk, therefore, when of the temperature 31° , will be $1-m$. By the loss of another degree of heat, its temperature will be reduced to 30° , and its contraction will not be m , as before, but $m(1-m)$, which, subtracted from $1-m$, its bulk, when of the temperature 31° , will give its bulk when of the temperature 30° , $= 1-2m+m^2 = (1-m)^2$. In like manner, after the loss of 3° of heat, the bulk of the same given quantity of air is shewn to be $(1-m)^3$; and, in general, its bulk is as that power of $1-m$, which is denoted by the difference between 32° and the given temperature. If, therefore, b be the heat of a given quantity of air, $(1-m)^{32-b}$ will be the space occupied by that air, supposing always that the compressing force is given.

6. THIS formula assigns a finite magnitude to the air as long as the diminution of its heat is less than infinite; for as $1-m$ is less than unity, when b becomes negative and infinite, $(1-m)^{32-b}$ becomes then, and not till then, $= 0$. When b is affirmative, and greater than 32 , $(1-m)^{32-b}$ becomes greater than 1 , and increases continually, being infinite when b is infinite. When $32-b$ is not very great, then $(1-m)^{32-b} = 1 + (b-32)m$ nearly, which agrees with the hypothesis of uniform contraction and dilatation in moderate temperatures.

THIS formula also represents, with tolerable exactness, the experiments which General ROY made with the manometer, ex-

cepting in one circumstance ; for the formula makes the expansion increase with the heat continually, though not uniformly ; whereas the experiments give the greatest expansion between the temperatures of 60° and 70° . But this seems to be so anomalous a fact, that it looks more like some accidental effect, produced from the particular manner of making the experiments, than a part of that law of nature, which connects the variations of bulk in bodies with their variations of temperature.

7. BUT this is not the only irregularity to which the expansion of air by heat, and its contraction by cold, appear to be subject. We learn from the manometrical experiments of the same excellent observer, that a given variation of temperature is accompanied with more or less variation of bulk, according as the air is compressed by a greater or a less force. Air, for instance, compressed by the weight of an entire atmosphere, was expanded by the 180 degrees from freezing to boiling, no less than 484 of those parts, whereof, at the temperature 32° , it occupied 1000. But the same air, when compressed only by $\frac{1}{5}$ of an atmosphere, was, by the same difference of heat, expanded no more than 141 parts ; and that though the heat of boiling water was applied to it for an hour together. It is not easy either to assign the cause, or to determine the law of this inequality. General ROY has, indeed, constructed a table of the correction to be made on account of it ; which proceeds on the supposition, that the expansion, for one degree of heat, decreases in the same proportion that the column of mercury in the barometer exceeds a given length. This given length is nearly = 4.5 inches ; so that if b be the length of the column of mercury in the barometer, and .00252 the expansion for one degree of heat, when the barometer is at 30 inches, and the temperature of the air 32° , then $\frac{b-4.5}{25.5} \times .00252$, will be the expansion of air of the same temperature, for the same change of heat, when

when the mercury in the barometer stands at the height b . But this formula cannot be just, otherwise air, compressed by no greater a force than that of 4.5 inches of mercury, would be incapable of dilatation by heat, or contraction by cold.

8. It will agree equally well with the experiments, and will involve no contradiction, even in the extreme cases, to suppose, that the expansion for a certain degree of heat is as a certain power of the compressing force. If this power be called μ , m being the expansion for 1 degree of heat, when the mercury in the barometer is of the height b , the expansion for any other

height of the mercury, as β , will be $\frac{\beta^\mu}{b^\mu} m$; and combining this with the former formula for expansion (§ 5.), we have the space which air occupies, as far as it depends on temperature,

$$= \left(1 - \frac{m\beta^\mu}{b^\mu}\right)^{32-b}. \quad \text{From a comparison of General ROY's expe-}$$

riments *, μ appears to be between $\frac{1}{2}$ and $\frac{1}{3}$; and it must be confessed, that it is very difficult to assign its value within nearer limits. The form of the correction, however, if not its absolute quantity, may be found from what is here determined. The last of these must be ascertained by future experiments.

9. THESE inequalities belong to the temperature of the air; there is another that depends wholly on the compression. In deducing the rule for the measurement of heights by the barometer, it has hitherto been supposed, agreeably to the experiments of Mr BOYLE and M. MARIOTTE, that the density of the air, while its temperature remains the same, is exactly as the force that compresses it. But the experiments referred to were not accurate enough to establish this law with absolute precision; and they left room to suspect a deviation from it, either when the compressing force is very great or very small. Accordingly, from experiments described in the 9th vol. of the Mem. of Berlin, it appears that the elasticity of air of the tempera-

ture

* Tab. 2. and 3. p. 701. 703. Transf. 1777. part 2.

ture 55° , or the compressing force, increases more slowly than the density; so that, if the compressing force be doubled, the density will exceed the double by about a tenth part, &c. The law of this variation is expressed with tolerable exactness, by supposing, that if D be the density of the air, and F the force compressing it, then $D = F^{1+n}$, n being a very small fraction, nearly .0015.

10. IT must be acknowledged, that new experiments are necessary to ascertain the law of this inequality with precision.

But as the formula $D = F^{1+n}$ is very general, and might be rendered still more so, without affecting the method of integration that is to be employed, the result of that integration may be useful when our physical knowledge becomes more accurate. In the mean time, it may not be improper to remark, that the precise knowledge of the law which connects the compressing force with the density of elastic fluids, is an object well deserving the attention of natural philosophers. The determination of that law may go far to decide the question, whether the particles of such fluids are in contact or not; that is, whether the elasticity of each particle be a force that extends beyond the nearest particles, like the forces of magnetism and gravitation; or one which, like that of a spring, extends only to the bodies which are next it. It is an enquiry, therefore, of no less importance in general physics than in that particular subject which we have here undertaken to examine.

11. THERE is one other correction to be applied to the height of a mountain, as it is usually found from observations of the barometer. This arises from the diminution of gravity, whether we ascend or descend from the surface of the earth. The effect of that diminution is to produce a twofold error; because, on the supposition of uniform gravity, the weight of each particle of air is computed too great, and the weight of the column of mercury in the barometer, that is not on the surface, is also

also reckoned too great. The effect of both these errors is of the same kind, tending to make the height less than it is in reality; yet it is only the first of them, and that too the least considerable, which has hitherto been taken into account.

12. It were to be wished, that, to the causes here enumerated, and that are to be introduced into the computation, we could add the operation of moisture, in altering the weight and elasticity of the air. But the law of that operation has not yet been discovered; and it will be sufficient to point out, in the conclusion of this paper, a method by which it may be determined from observations of the barometer itself.

BEFORE proceeding to the investigation of the effect which all these inequalities together must produce, it is proper to remark, that the two inequalities in the expansion of air, taken notice of (§ 5. and 7.), after having been discovered by General ROY, were applied by him to correct the height of mountains, measured by the barometer; but that it is, by no means, certain, that he has given to those corrections the precise form which they ought to have. This, indeed, cannot be known, unless the effect of each inequality, on a single stratum, be first introduced into the differential equation between the density of the air and the height above the surface, and the amount of its effect on a whole column of air be deduced from thence by integration.

13. LET y , then, be the density of the air, at any height x above the surface of the earth, the heat at the surface being $= H$, expressed in degrees of FAHRENHEIT'S thermometer. If also λ be such a number, that λx gives the degrees by which the thermometer stands lower at the height x than at the surface (§ 4.), the temperature at the height x will be $= H - \lambda x$; and, if the expansion of a given quantity of air, which occupies the space 1, and is of the temperature 32° , for 1° of heat, be called m , then, abstracting at present from that inequality of expansion.

expansion which depends on pressure, we have the space occupied by that same quantity of air, when it is of the temperature

$H - \lambda x$, equal to $(1-m)^{32-H+\lambda x}$: Or, making $32-H=\tau$, we have the required space $= (1-m)^{\tau+\lambda x}$.

Now, if the given quantity of air, of which the bulk has been supposed $= 1$, and the temperature $= 32^\circ$, be compressed by a column of air of the same density and temperature with itself, but of the height p , and if its density, in this case, be also called 1 ; then, in the case of its having any other temperature, as $H - \lambda x$, and being compressed by any other force, as $-fyx$, or the weight of the superincumbent air at the height x ,

we have $1 : y :: p : \frac{-fyx}{(1-m)^{\tau+\lambda x}}$, and likewise

$$y = \frac{-fyx}{p(1-m)^{\tau+\lambda x}}.$$

No account is here taken of the diminution of gravity, any more than of the departure of the law of the elasticity of air from direct proportionality to the density (§ 8.), because it is convenient to consider the problem at first under the more simple view, where only the two first inequalities are introduced.

13. SINCE $y = \frac{-fyx}{p(1-m)^{\tau+\lambda x}}$ we have

$$py(1-m)^{\tau+\lambda x} = -fyx, \text{ and}$$

$$p\dot{y}(1-m)^{\tau+\lambda x} + p\lambda y(\log. 1-m)(1-m)^{\tau+\lambda x} \dot{x} = -y\dot{x},$$

$$\text{Or, } \frac{p\dot{y}}{y} + p\lambda \log.(1-m) \dot{x} = -\frac{\dot{x}}{(1-m)^{\tau+\lambda x}}.$$

Hence

Hence, making $\log.(1-m) = g$,

$$\frac{p\dot{y}}{y} = -p\lambda g\dot{x} - \frac{\dot{x}}{(1-m)^{\tau+\lambda x}}, \text{ and}$$

$$p\log.y + p\log.C = -p\lambda gx + \frac{1}{\lambda g(1-m)^{\tau+\lambda x}}.$$

If D denote the density of the air at the surface of the earth, D will be the value of y , when $x = 0$, and so

$$p(\log.D + \log.C) = \frac{1}{\lambda g(1-m)^{\tau}}. \text{ Therefore}$$

$$p\log.C = \frac{1}{\lambda g(1-m)^{\tau}} - p\log.D; \text{ and so by substituting for}$$

$$p\log.C, p(\log.y - \log.D) + \frac{1}{\lambda g(1-m)^{\tau}} = -p\lambda gx + \frac{1}{\lambda g(1-m)^{\tau+\lambda x}};$$

or changing the signs,

$$p(\log.D - \log.y) - \frac{1}{\lambda g(1-m)^{\tau}} = p\lambda gx - \frac{1}{\lambda g(1-m)^{\tau+\lambda x}}.$$

THIS equation exhibits, in general, the relation between the density of any stratum of air, and the height of that stratum above the surface of the earth, on the suppositions that the heat of the atmosphere decreases uniformly as we ascend, and that the contraction produced in air by cold, observes the law described in § 5. It might be considered as an equation to a curve, of which the abscissæ represented the height of the different strata of the atmosphere, and the ordinates, the densities of those strata: This curve would evidently be different from the logarithmic, but would be found to have certain relations to it not uninteresting, and not difficult to trace, if we had leisure for such a digression.

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14. LET

14. LET us now suppose that z is the whole height to be measured, and that Δ is the density at that height, the temperature there being also found $= b$, by observation. If then x become $= z$, and $y = \Delta$, we will also have $\lambda z = H - b$, and $\tau + \lambda z = 32 - H + H - b = 32 - b = r - b$, making $r = 32$. Also $\lambda = \frac{H - b}{z}$.

Therefore, by substituting these values of y , x , λ , and $\tau + \lambda z$, in the preceding equation, we have,

$$p(\log. D - \log. \Delta) - \frac{z}{g(H - b)(1 - m)} =$$

$$\frac{pg(H - b) - \frac{z}{r - b}}{g(H - b)(1 - m)}$$

Hence, by transposition, &c.

$$gp(H - b)(\log. D - \log. \Delta - (H - b)g) = z \left((1 - m)^{\frac{H - r}{r - b}} - (1 - m)^{\frac{b - r}{r - b}} \right);$$

$$\text{and } x = \frac{gp(H - b)(\log. D - \log. \Delta - (H - b)g)}{(1 - m)^{\frac{H - r}{r - b}} - (1 - m)^{\frac{b - r}{r - b}}}.$$

THUS the height of any column of air is expressed in terms of the density, and of the temperature at the top and bottom of it; the equation for the height, though an exponential one in its general form, admitting of an easy resolution, from the circumstance of λz being given by the observations of the thermometer.

15. THAT this formula may be applied to the measurement of heights, it is necessary to introduce into it the lengths of the columns of mercury in the barometer, instead of the densities of the air, at the lower and upper stations. Let b be the height at which the mercury stands in the lower barometer, and β that at which it stands in the higher barometer; then, since b is the compressing force at the surface of the earth, we have

$$D =$$

$$D = \frac{b}{(1-m)^{r-H}}; \text{ and, for a like reason, } \Delta = \frac{\beta}{(1-m)^{r-b}}. \text{ There-}$$

fore, $\log. D = \log. b - (r-H)g$, and $-\log. \Delta = -\log. \beta + (r-b)g$. Hence $\log. D - \log. \Delta = \log. b - \log. \beta + (H-b)g$, and substituting for $\log. D - \log. \Delta$ in the formula of the last section,

$$z = \frac{gp(H-b)(\log. b - \log. \beta)}{(1-m)^{H-r} - (1-m)^{b-r}}.$$

16. THIS is the exact value of z , or of the whole height to be measured, on the supposition that the heat of the atmosphere decreases uniformly as the height increases; and that the contraction for a given difference of heat decreases according to the law described in § 5. But, in order that it may be more convenient for computation, and may be more easily compared with the formula now in use, the quantity $\frac{1}{(1-m)^{H-r} - (1-m)^{b-r}}$

must be reduced into a series. Now $\frac{1}{(1-m)^{H-r} - (1-m)^{b-r}} =$

$$\frac{(1-m)^r}{(1-m)^H - (1-m)^b}. \text{ But from the nature of logarithms, (} g \text{ being,}$$

as before, the logarithm of $1-m$)

$$(1-m)^H = 1 + Hg + \frac{H^2 g^2}{2} + \frac{H^3 g^3}{6} + \mathcal{C}c. \text{ And}$$

$$-(1-m)^b = -1 - bg - \frac{b^2 g^2}{2} - \frac{b^3 g^3}{6} - \mathcal{C}c. \text{ Therefore}$$

$$\frac{(1-m)^r}{(1-m)^H - (1-m)^b} = \frac{1 + rg + \frac{r^2}{2}g^2 + \frac{r^3}{6}g^3 + \mathcal{C}c.}{(H-b)g + \frac{H^2 - b^2}{2}g^2 + \frac{H^3 - b^3}{6}g^3 + \mathcal{C}c.};$$

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and

$$\text{and } \frac{g(H-b)(1-m)^r}{(1-m)^H - (1-m)^b} = \frac{1+rg+\frac{r^2}{2}g^2+\frac{r^3}{6}g^3+\mathcal{O}c.}{1+\frac{H+b}{2}g+\frac{H^2+Hb+b^2}{6}g^2+\mathcal{O}c.}.$$

$$\text{Hence } z = p(\log. b - \log. \beta) \left(\frac{1+rg+\frac{r^2}{2}g^2+\frac{r^3}{6}g^3+\mathcal{O}c.}{1+\frac{H+b}{2}g+\frac{H^2+Hb+b^2}{6}g^2+\mathcal{O}c.} \right).$$

17. THESE series will not converge fast, unless rg , Hg , and bg , be all of them quantities much less than unity. Now, as m , or the expansion of air of the temperature r , for 1° of heat, is, in fact, very small, being nearly $= .00245$, and as g , or the logarithm of $1-m$, must, of consequence, be nearly $= -m = -.00245$, it is plain, that, in all moderate temperatures, these series will converge with great rapidity; though, in extreme cases, where z is supposed vastly great, and where b may be negative, and also great, the series in the denominator may converge so slowly that recourse must be had to the formula in § 15. from which no quantities are rejected.

WHEN m , and, of consequence, g , are very small, and when H and b do not differ much from r , the preceding formula, agreeably to a remark in § 6. will comprehend the case of uniform expansion, and will give the same expression for the height, that would be derived from considering only the equable decrease of heat as we ascend in the atmosphere. Now, as in the case supposed, we may reject all the powers of g but the first, and may also suppose $g = -m$, we have

$$z = p(\log. b - \log. \beta) \left(\frac{1-rm}{1-\frac{H+b}{2}m} \right), \text{ or}$$

$$z = p\left(1 + \left(\frac{H+b}{2} - r\right)m\right)(\log. b - \log. \beta).$$

18. THIS

18. THIS last is precisely the formula of M. DE LUC, if we give to p , r , and m , the proper values *. It was discovered by that ingenious and indefatigable observer, without any enquiry into the propagation of heat through the atmosphere, the principle on which it depends; and, that so near an approximation to the truth should have been thus obtained, is to be considered as a singular instance of sagacity or of good fortune. For if the heat of the air diminished, not in the simple ratio of the increase of the height, but in that of any power of it, so as to be expressed by $H - \lambda x^n$, then, by computing as has been done above, we should find $z = p(1+m(\frac{nH+b}{n+1} - r)) \log. \frac{b}{\beta}$. Here the temperature from which r , or the first temperature, is to be subtracted, is not $\frac{H+b}{2}$, but $\frac{nH+b}{n+1}$; and this is a formula which conjecture or experiment alone would scarcely have discovered.

It is farther to be remarked of the formula $z = p(1+m(\frac{H+b}{2} - r)) \log. \frac{b}{\beta}$, that it is rigorously just, if we suppose the temperature $\frac{H+b}{2}$ to be uniformly diffused through the column of air, of which the height is to be measured, as is done by Dr HORSLEY in his theory of M. DE LUC's rules †; but that, on a supposition, more conformable to nature, of the heat diminishing in the same proportion as the height increases, it is only an approximation to the truth, or the first term of a series, whereof the other terms are rejected as inconsiderable.

19. THE

* If we take M. DE LUC's rule, as improved by the later observations of General ROY and Sir GEORGE SHUCKBURGH, $p = 4342.9448$ = the modulus of the tabular logarithms multiplied by 10000: $r = 32^\circ$ and $m = .00245$ nearly. It is unnecessary to remark, that the logarithms understood in all these formulas are hyperbolic logarithms, and that the multiplication of them by p is saved, by using the tabular logarithms, and making the first four places of them, excluding the index, integers.

† Phil. Transf. vol. 64. part 1.

19. THE amount of the terms which are thus rejected comes now to be considered; and it will be ascertained with sufficient accuracy, if we compute the second term of the series, or that which involves in it m^2 . Now;

$$\frac{1 + rg + \frac{r^2}{2}g^2 + \mathcal{O}c.}{1 + \frac{H+b}{2}g + \frac{H^2 + Hb + b^2}{6}g^2 + \mathcal{O}c.} =$$

$$1 + \left(r - \frac{H+b}{2}\right)g + \left(\frac{r^2 - r(H+b)}{2} + \frac{H^2 + 4Hb + b^2}{12}\right)g^2;$$

$$\text{and } g = \log.(1-m) = -m + \frac{m^2}{2} - \mathcal{O}c.$$

$$\text{so that } g^2 = m^2 - \mathcal{O}c.$$

$$\text{Therefore, by substitution, } \frac{1 + rg + \frac{r^2}{2}g^2}{1 + \frac{H+b}{2}g + \frac{H^2 + Hb + b^2}{6}g^2} =$$

$$1 + \left(\frac{H+b}{2} - r\right)m + \left(\frac{r}{2} - \frac{H+b}{4} + \frac{r^2 - r(H+b)}{2} + \frac{H^2 + 4Hb + b^2}{12}\right)m^2.$$

THIS is the coefficient of $p \log. \frac{b}{\beta}$, which gives z , corrected both for the temperature of the air and the first inequality of expansion, (§ 5). The term $\left(\frac{H+b}{2} - r\right)m$, is M. DE LUC's correction, as has been already observed, the third term, viz. $\left(\frac{r}{2} - \frac{H+b}{4} + \frac{r^2 - r(H+b)}{2} + \frac{H^2 + 4Hb + b^2}{12}\right)m^2$, contains not only a part which depends on the equable decrease of heat as we ascend in the atmosphere, but also one which arises from the above mentioned inequality of expansion.

20. THE term involving m^2 , that has now been computed, will rarely amount to any thing considerable. The coefficient of it vanishes when both H and b are equal to r , but increases as these two quantities recede from r on either side. In no instance where the barometer is to be applied to actual measurement, will the correction probably be found greater than in determining the height of Coraçon above the level of the South Sea, where H , or the height of the thermometer at that level, was $84^{\circ}\frac{1}{2}$, and b , or the height of the thermometer at the top of the mountain, $43^{\circ}\frac{1}{2}$; the coefficient of m^2 comes out, in this case $+426$, and m^2 being $=.000006 = (.00245)^2$, the correction $=.00259$, or nearly $\frac{1}{400}$ of the height of the mountain, as found before any correction was applied, or $= 40$ feet nearly. It is to be remarked, too, that, for every value of H , or of the temperature at the lower station, there are two values of b , or the temperature at the upper station, that make the coefficient, $\frac{r}{2} - \frac{H+b}{4} + \frac{r(r-H-b)}{2} + \frac{H^2+4Hb+b^2}{12}$, and, of consequence, the correction depending on it equal to nothing. This is evident from the nature of the coefficient; but, as the law by which this last increases and decreases is, by no means, simple, it were convenient to have it reduced into a table, for the different values that might be assigned to H and b , from which it would be immediately obvious in what cases it was to be taken into account, and when it might safely be omitted.

BUT though this correction may sometimes be of consequence enough to be included in the measurement of heights, it is certain that it may be safely neglected in the computation of the other corrections. For the error thereby committed in the estimation of a new correction, will be nearly the same part of the former correction, that the new one is of the whole height. If, for instance, the new correction be $\frac{1}{100}$ of the whole

whole height, the error committed in estimating it will be but $\frac{1}{100}$ of the former correction; and, if that did not exceed $\frac{1}{400}$, the error in question will not exceed $\frac{1}{40000}$ of the whole height.

21. IN computing the effect of the second inequality of expansion, described § 8. we may, therefore, abstract from the last inequality, and may even suppose, with M. DE LUC, that the temperature, which is a mean between those of the extremities of a column of air, is uniformly diffused through that column. Let the excess of that mean, above the temperature r , or $\frac{H+b}{2} - r = f$; and let β , the height of the mercury in the uppermost barometer, be considered as variable. Then taking the formula of § 8. and supposing m to be the expansion for 1° of heat, when the mercury in the barometer is of a given height, which we shall here call γ^* , (to avoid the confusion that would arise from naming it, as in the art. above referred to) and retaining all the other denominations as before, we have

$$y = \frac{-f y \dot{x}}{p \left(1 + \frac{fm}{\gamma^\mu} \beta^\mu\right)}.$$

Hence $py \left(1 + \frac{fm}{\gamma^\mu} \beta^\mu\right) = -f y \dot{x}$, so that, taking the fluxions,

$p \dot{y}$

* According to the experiments of General ROY, above quoted, the expansion of air, for 1° of heat, at the temperature 32° , is .00245 nearly, that air being compressed at the same time by the weight of a column of mercury 29.5 inches high. As we have supposed m , in the preceding computations, to be .00245, we must suppose $\gamma = 29.5$. The formula supposed here to give the space occupied by the air, so far as heat is concerned, viz. $1 + \frac{fm}{\gamma^\mu} \beta^\mu$, is changed from the exponential expression of § 8. in consequence of what has been just observed about the effect of neglecting one inequality in the computation of another.

$$p\dot{y} + \frac{p f m \beta^{\mu} \dot{y}}{\gamma^{\mu}} + \frac{p f m \mu y \beta^{\mu-1} \dot{\beta}}{\gamma^{\mu}} = -y\dot{x}, \text{ and, dividing by } y,$$

$$\dot{x} = -\frac{p\dot{y}}{y} - \frac{f m p \beta^{\mu} \dot{y}}{\gamma^{\mu} y} - \frac{\mu f m p \beta^{\mu-1} \dot{\beta}}{\gamma^{\mu}}.$$

To exterminate from this equation y and $\dot{y}$, it is to be remarked, that $y = \frac{\beta}{p(1 + \frac{f m}{\gamma^{\mu}} \beta^{\mu})}$, and that therefore

$$\frac{\dot{y}}{y} = \frac{\dot{\beta}}{\beta} - \frac{\mu f m \beta^{\mu-1} \dot{\beta}}{\gamma^{\mu} + f m \beta^{\mu}}. \text{ Hence, by substitution, } \dot{x} =$$

$$p \left(-\frac{\dot{\beta}}{\beta} + \frac{\mu f m \beta^{\mu-1} \dot{\beta}}{\gamma^{\mu} + f m \beta^{\mu}} - \frac{(1 + \mu) f m \beta^{\mu-1} \dot{\beta}}{\gamma^{\mu}} + \frac{\mu f^2 m^2 \beta^{2\mu-1} \dot{\beta}}{\gamma^{\mu} (\gamma^{\mu} + f m \beta^{\mu})} \right).$$

$$\text{But } \frac{\mu f^2 m^2 \beta^{2\mu-1} \dot{\beta}}{\gamma^{\mu} (\gamma^{\mu} + f m \beta^{\mu})} = \frac{\mu f m \beta^{\mu-1} \dot{\beta}}{\gamma^{\mu}} - \frac{\mu f m \beta^{\mu-1} \dot{\beta}}{\gamma^{\mu} + f m \beta^{\mu}};$$

therefore $\dot{x} = p \left(-\frac{\dot{\beta}}{\beta} - \frac{f m \beta^{\mu-1} \dot{\beta}}{\gamma^{\mu}} \right)$, the other terms destroying

one another. By integration, then, $x = p \left(-\log. \beta - \frac{f m \beta^{\mu}}{\mu \gamma^{\mu}} + C \right)$.

If C be taken such that x may vanish when $\beta = b$, the height of the mercury in the lower barometer, we will have

$$x = p \left(\log. \frac{b}{\beta} + \frac{f m (b^{\mu} - \beta^{\mu})}{\mu \gamma^{\mu}} \right).$$

O

22. THAT

22. THAT it may appear wherein this formula differs from the ordinary one, instead of b^μ and β^μ , we must introduce $\log. b$, and $\log. \beta$, which, when b and β are not very unequal, may be done without difficulty. For we have

$$\frac{b^\mu}{\gamma^\mu} = 1 + \mu \log. \frac{b}{\gamma} + \frac{\mu^2}{2} \left(\log. \frac{b}{\gamma} \right)^2 + \frac{\mu^3}{6} \left(\log. \frac{b}{\gamma} \right)^3 + \mathcal{E}c. ; \text{ also}$$

$$\frac{\beta^\mu}{\gamma^\mu} = 1 + \mu \log. \frac{\beta}{\gamma} + \frac{\mu^2}{2} \left(\log. \frac{\beta}{\gamma} \right)^2 + \frac{\mu^3}{6} \left(\log. \frac{\beta}{\gamma} \right)^3 + \mathcal{E}c. \quad \text{Therefore}$$

$$\frac{b^\mu - \beta^\mu}{\gamma^\mu} = \mu \left(\log. \frac{b}{\gamma} - \log. \frac{\beta}{\gamma} \right) + \frac{\mu^2}{2} \left(\left(\log. \frac{b}{\gamma} \right)^2 - \left(\log. \frac{\beta}{\gamma} \right)^2 \right) + \mathcal{E}c.$$

That is, $\frac{b^\mu - \beta^\mu}{\gamma^\mu} = \mu \log. \frac{b}{\beta} + \frac{\mu^2}{2} \log. \frac{b\beta}{\gamma^2} \times \log. \frac{b}{\beta}$, rejecting all the

terms which involve powers, of $\log. \frac{b}{\gamma}$, of $\log. \frac{\beta}{\gamma}$, and of μ , higher than the square. Hence also,

$$\frac{fm(b^\mu - \beta^\mu)}{\mu\gamma^\mu} = fm \log. \frac{b}{\beta} + \frac{\mu fm}{2} \log. \frac{b\beta}{\gamma^2} \times \log. \frac{b}{\beta}, \text{ and}$$

$$x = p \left(\log. \frac{b}{\beta} + \frac{fm(b^\mu - \beta^\mu)}{\mu\gamma^\mu} \right) =$$

$$p \left(\log. \frac{b}{\beta} + fm \log. \frac{b}{\beta} + \frac{\mu fm}{2} \log. \frac{b\beta}{\gamma^2} \times \log. \frac{b}{\beta} \right) ; \text{ or } x =$$

$$p \log. \frac{b}{\beta} \left(1 + fm + \frac{\mu fm}{2} \log. \frac{b\beta}{\gamma^2} \right).$$

23. THIS

23. THIS formula includes the correction to be made for that inequality of the expansion of air by heat which depends on its compression, and which was described at the 7th and 8th articles. The first term of the formula, *viz.* $p \log. \frac{b}{\beta}$, is the difference of the tabular logarithms of b and β . The second, *viz.* $fmp \log. \frac{b}{\beta}$, is M. DE LUC's correction, and the same that was already investigated, § 17. The third, *viz.* $\frac{\mu fm}{2} \log. \frac{b\beta}{\gamma^2} \times p \log. \frac{b}{\beta}$ is the correction for the above mentioned inequality of expansion. It is of a form very convenient for computation; for the former correction being = $fmp \log. \frac{b}{\beta}$, we need only multiply it by $\frac{\mu}{2} \log. \frac{b\beta}{\gamma^2}$ to have the third term of the formula, or the correction required. It must be remembered, that $\log. \frac{b\beta}{\gamma^2}$ signifies the hyperbolic logarithm of $\frac{b\beta}{\gamma^2}$.

THE exact amount of this correction cannot be known, till μ be defined by experiments on the expansibility of air under different degrees of compression; those which General ROY has made, though excellent, not being perfectly sufficient for that purpose. If we suppose $\mu = \frac{1}{2}$, and if, as an example, we take $b = 29$ inches, and $\beta = 24$, γ being = 29.5, then we will find $\log. \frac{b\beta}{\gamma^2} = -.22$ nearly, which, multiplied into $\frac{\mu}{2}$, or into $\frac{1}{4}$, is $-\frac{1}{16}$ nearly, and this multiplied into M. DE LUC's correction, gives the correction for the compression. The former is, therefore, to be diminished by $\frac{1}{16}$, before it be applied.

to the difference of the tabular logarithms, to give the true height of the one barometer above the other. In other cases, the proportional part, to be added or subtracted, will be greater as β becomes less, or as the height becomes greater: It will be $= 0$, when $b\beta = \gamma^2$; affirmative, when $b\beta$ is greater than γ^2 ; and negative when it is less.

24. THERE remain to be considered the two corrections that depend, one, on the relation between the density of the air and the force compressing it; the other, on the diminution of gravity as we ascend from the surface of the earth. It was observed (§ 9.), that, if D denote the density of the air, and F

the compressing force, $D = F^{1+n}$. But the force, compressing a stratum of the atmosphere at the height x above the surface of the earth, and of the density y , which, on the supposition of uniform gravity, is denoted by $-\int yx$, on that of gravity decreasing as the v power of the distance from the centre of the

earth, is denoted by $-\int \frac{s^v}{(s+x)^v} yx$; where s is the femidiameter

of the earth. This is evident, because the weight of each stratum of air is proportional to its density, multiplied into the accelerating force which draws the particles of it toward the earth. Now, let q be the length of such a column of mercury, that air, compressed by it, would be of the same density with the mercury itself, which density, in all the preceding investigations, is understood to be constant, and to be $= 1$ *;

then,

* THE mercury in the barometers is supposed to be reduced to a fixed temperature, by the application of a correction on account of the thermometers attached to them, after the manner of M. DE LUC, or of General ROY; the latter reduces the mercury always to the temperature of 32° . When the difference of temperature is not very great in the two barometers, the correction of their heights may be made according to the very ingenious remark of the astronomer royal. *Phil. Transf. vol. 64. part 1. p. 164.*

then, $I : y :: q^{\frac{I+n}{\tau+\lambda x}} : \frac{\left(-\int \frac{s^v}{(s+x)} y \dot{x} \right)^{\frac{I+n}{\tau+\lambda x}}}{(I-m)^{\frac{I+n}{\tau+\lambda x}}}$, and

$$y = \frac{\left(-\int \frac{s^v}{(s+x)} y \dot{x} \right)^{\frac{I+n}{\tau+\lambda x}}}{q^{\frac{I+n}{\tau+\lambda x}} (I-m)^{\frac{I+n}{\tau+\lambda x}}}, \quad \text{or } y^{\frac{I}{I+n}} = \frac{-\int \frac{s^v}{(s+x)} y \dot{x}}{q (I-m)^{\frac{I}{I+n}}}.$$

In which formula, all the inequalities that have been enumerated are expressed, except that which was considered in the two preceding articles. Hence, multiplying by $q(r-m)^{\frac{\tau+\lambda x}{I+n}}$, and taking the fluxions, there comes out,

$$q \left(\frac{I}{I+n} y^{\frac{I}{I+n}-1} \dot{y} (I-m)^{\frac{\tau+\lambda x}{I+n}} + \frac{\lambda g}{I+n} y^{\frac{I}{I+n}} (I-m)^{\frac{\tau+\lambda x}{I+n}} \dot{x} \right) = - \frac{s^v y \dot{x}}{(s+x)}.$$

Dividing therefore by y ,

$$q \left(\frac{I}{I+n} y^{\frac{I}{I+n}-2} \dot{y} (I-m)^{\frac{\tau+\lambda x}{I+n}} + \frac{\lambda g}{I+n} y^{\frac{I}{I+n}-1} (I-m)^{\frac{\tau+\lambda x}{I+n}} \dot{x} \right) = - \frac{s^v \dot{x}}{(s+x)}; \text{ and making } y^{\frac{I}{I+n}-1} = v, \text{ and, consequently,}$$

$$\frac{-n}{I+n} y^{\frac{I}{I+n}-2} \dot{y} = \dot{v}, \text{ we have}$$

$$\dot{v} (I-m)^{\frac{\tau+\lambda x}{I+n}} - \frac{n \lambda g}{I+n} v (I-m)^{\frac{\tau+\lambda x}{I+n}} \dot{x} = \frac{n s^v \dot{x}}{q (s+x)}.$$

This

This equation will become integrable if it be multiplied by $(1-m)^{-\lambda x}$, for it is then

$$\dot{v} (1-m)^{\frac{\tau-n\lambda x}{1+n}} - \frac{n\lambda g}{1+n} v (1-m)^{\frac{\tau-n\lambda x}{1+n}} \dot{x} = \frac{n s^y \dot{x}}{q (s+x) (1-m)^{\lambda x}};$$

$$\text{and so } v (1-m)^{\frac{\tau-n\lambda x}{1+n}} + C = \frac{n s^y}{q} \int \frac{\dot{x}}{(s+x) (1-m)^{\lambda x}}.$$

$$\text{But } v = y^{\frac{1}{1+n}} = y^{-\frac{n}{1+n}}, \text{ therefore,}$$

$$y^{-\frac{n}{1+n}} (1-m)^{\frac{\tau-n\lambda x}{1+n}} + C = \frac{n s^y}{q} \int \frac{\dot{x}}{(s+x) (1-m)^{\lambda x}}.$$

25. It is necessary to introduce β into this formula, by sub-

$$\text{stituting for } y, \text{ its value, } = \frac{\left(\frac{s^y}{(s+x)} \beta \right)^{1+n}}{q (1-m)^{\frac{\tau+\lambda x}{1+n}}}; \text{ and, therefore, as}$$

$$y^{\frac{n}{1+n}} = \frac{s^{\frac{n}{1+n}} \beta^{\frac{n}{1+n}}}{q (s+x)^{\frac{n}{1+n}} (1-m)^{\frac{n(\tau+\lambda x)}{1+n}}}, \text{ we have}$$

$$\frac{s^{\frac{n}{1+n}} \beta^{\frac{n}{1+n}}}{q (s+x)^{\frac{n}{1+n}} (1-m)^{\frac{n(\tau+\lambda x)}{1+n}}} \times (1-m)^{\frac{\tau-n\lambda x}{1+n}} + C = \frac{n s^y}{q} \int \frac{\dot{x}}{(s+x) (1-m)^{\lambda x}},$$

or

$$\text{or, } \frac{q (s+x)^{\frac{n}{\beta}} (1-m)^{\frac{\tau}{\beta}}}{s^{\frac{2n}{\beta}}} + C = \frac{ns^{\frac{\nu}{\beta}}}{q} \int \frac{\dot{x}}{(s+x)^{\frac{\nu}{\beta}} (1-m)^{\frac{\lambda x}{\beta}}}.$$

26. IN the cases which actually take place in nature, ν is either equal to $+2$, or to -1 . It is equal to $+2$, when the barometer is raised above the surface of the earth, and to -1 , when it is depressed below it. When $\nu = +2$, the last equation becomes

$$\frac{q (s+x)^{\frac{2n}{\beta}} (1-m)^{\frac{\tau}{\beta}}}{s^{\frac{2n}{\beta}}} + C = \frac{ns^2}{q} \int \frac{\dot{x}}{(s+x)^2 (1-m)^{\lambda x}}.$$

When x is supposed very small in comparison of s , the fluent $\int \frac{\dot{x}}{(s+x)^2 (1-m)^{\lambda x}}$ may be expressed by a series, converging with

such rapidity, that the two first terms will be sufficient for the

present purpose. Now, as $\frac{1}{(s+x)^2} = \frac{1}{s^2 (1 + \frac{x}{s})^2} =$

$$\frac{1}{s^2} \left(1 - \frac{2x}{s} \right) \text{ nearly, } \frac{ns^2}{q} \int \frac{\dot{x}}{(s+x)^2 (1-m)^{\lambda x}} \text{ becomes}$$

$$= \frac{n}{q} \int (1-m)^{-\lambda x} \dot{x} \left(1 - \frac{2x}{s} \right) = \frac{n}{q(1-m)^{\lambda x}} \left(-\frac{1}{\lambda g} + \frac{2x}{\lambda g s} + \frac{2}{\lambda^2 g^2 s} \right).$$

$$\text{Therefore, } \frac{q (s+x)^{\frac{2n}{\beta}} (1-m)^{\frac{\tau}{\beta}}}{s^{\frac{2n}{\beta}}} + C =$$

$$\frac{n}{q(1-m)^{\lambda x}} \left(-\frac{1}{\lambda g} + \frac{2x}{\lambda g s} + \frac{2}{\lambda^2 g^2 s} \right). \text{ To define } C, x \text{ must be put}$$

$$= 0,$$

= 0, and $\beta = b$, so that

$$\frac{q (1-m)^{\tau}}{b^n} + C = \frac{n}{q} \left(-\frac{1}{\lambda g} + \frac{2}{\lambda^2 g^2 s} \right), \text{ and } C =$$

$$-\frac{q (1-m)^{\tau}}{b^n} + \frac{n}{q} \left(-\frac{1}{\lambda g} + \frac{2}{\lambda^2 g^2 s} \right). \text{ If this value be substituted for}$$

C , and if all the terms be divided by $(1-m)^{\tau}$, we shall have

$$\frac{q (s+x)^{2n}}{s^{2n} \beta^n} - \frac{q}{b^n} = \frac{n}{q \lambda g} \left(\frac{1}{(1-m)^{\tau}} - \frac{1}{(1-m)^{\tau+\lambda x}} + \frac{2x}{s(1-m)^{\tau+\lambda x}} - \right.$$

$$\left. \frac{2}{\lambda g s (1-m)^{\tau}} + \frac{2}{\lambda g s (1-m)^{\tau+\lambda x}} \right).$$

THE approximation which has been used here for finding the fluent $\int \frac{\dot{x}}{(s+x)^2 (1-m)^{\lambda x}}$, is sufficiently exact, because no terms have been rejected but such as are divided by s^2 , and which, of consequence, are extremely small in respect of the rest.

27. WE are now to suppose, that x becomes equal to z , or to the whole height that is to be measured; then also,

$$\tau + \lambda x = r - b, \lambda = \frac{H-b}{z}, \text{ and } \tau = r - H, \text{ as in } \S 14.;$$

$$\text{and so by substitution, } \frac{q (s+z)^{2n}}{s^{2n} \beta^n} - \frac{q}{b^n} =$$

$$\frac{nz}{qg(H-b)(1-m)}$$

$$\begin{aligned} & \frac{nz}{qg(H-b)(1-m)} \left(1 - \frac{1}{(1-m)^{H-b}} - \frac{2z}{gs(H-b)} + \right. \\ & \left. \frac{2z}{s(1-m)^{H-b}} + \frac{2z}{gs(H-b)(1-m)^{H-b}} \right) = \frac{nz}{qg(H-b)} \left((1-m)^{H-r} - \right. \\ & \left. (1-m)^{b-r} - \frac{2z}{gs(H-b)} (1-m)^{H-r} + \frac{2z}{s} (1-m)^{b-r} + \right. \\ & \left. \frac{2z}{gs(H-b)} (1-m)^{b-r} \right). \end{aligned}$$

THE value of z is to be found from this equation; and as the first step in the approximation, we may suppose s so great in respect of z , that $s+z = s$, nearly; and, also, that all the terms divided by s vanish; which, in fact, is the same thing with supposing the force of gravity to be uniform. We have, then,

$$\frac{q^n}{\beta^n} - \frac{q^n}{b^n} = \frac{nz}{qg(H-b)} \left((1-m)^{H-r} - (1-m)^{b-r} \right), \text{ or,}$$

$$z = \frac{\frac{1}{n} q^{1+n} g(H-b) \left(\frac{1}{\beta^n} - \frac{1}{b^n} \right)}{(1-m)^{H-r} - (1-m)^{b-r}}.$$

28. THIS is the exact value of z , on the supposition that gravity is uniform, and that the elasticity of the air is not simply as its density, but as the power of it denoted by $\frac{1}{1+n}$. But if we content ourselves with an approximation, which the smallness of n renders easy, the logarithms of b and β may be introduced,

introduced, and the formula will become similar to that which was formerly investigated. For $\frac{1}{\beta^n}$, or

$\beta^{-n} = 1 - n \log. \beta + \frac{n^2}{2} (\log. \beta)^2 - \frac{n^3}{6} (\log. \beta)^3 + \&c.$ When n is very small, as in the present case, this series converges with extreme rapidity; and the terms involving n^3 , $\&c.$ may safely be rejected. Therefore,

$$\frac{1}{\beta^n} - \frac{1}{b^n} = 1 - n \log. \beta + \frac{n^2}{2} (\log. \beta)^2 - 1 + n \log. b - \frac{n^2}{2} (\log. b)^2 =$$

$$n(\log. b - \log. \beta) - \frac{n^2}{2} ((\log. b)^2 - (\log. \beta)^2).$$

$$\text{Hence, } z = \frac{q^{1+n} (H-b) \left(\log. b - \log. \beta - \frac{n}{2} (\log. b)^2 + \frac{n}{2} (\log. \beta)^2 \right)}{(1-m)^{H-r} - (1-m)^{b-r}}$$

29. WHEN n vanishes altogether, the value of z , assigned by this formula, coincides, as it ought to do, with that which was investigated, on the supposition of the density being precisely as the compression; for by applying the reduction of art. 17. we have,

$$z = q \left(1 + m \left(\frac{H+b}{2} - r \right) \right) \log. \frac{b}{\beta}.$$

But when n , though very small, does not vanish altogether, by the same reduction,

$$z = q^{1+n} \left(1 + m \left(\frac{H+b}{2} - r \right) \right) \log. \frac{b}{\beta} \left(1 - \frac{n}{2} \log. b \beta \right).$$

If, therefore, we suppose q^{1+n} to be equal to p , or to 4343 fathoms,

fathoms, which must be nearly true; and, if we call A the height, or the value of z , computed from the formula $z = p \left(1 + m \left(\frac{H+b}{2} - r \right) \right) \log. \frac{b}{\beta}$, the correction to be applied on account of n , will be $-\frac{n}{2} A \log. b \beta$.

30. It is not, however, now a matter of indifference in what measure the lengths of the columns of mercury in the barometers are expressed, as it was, when only the ratios of these columns entered into the computation. They must be expressed in terms of the same measure, wherein the height of the mountain is required, and wherein q has been already determined. For, if we take the exact expression for the height, *viz.*

$$z = \frac{\frac{1}{n} q^{1+n} g(H-b) \left(\frac{1}{\beta^n} - \frac{1}{b^n} \right)}{(1-m)^{H-r} - (1-m)^{b-r}}, \text{ or that to which it may be re-}$$

$$\text{duced, } z = q \left(1 + m \left(\frac{H+b}{2} - r \right) \right) \left(\frac{q^n}{n\beta} - \frac{q^n}{nb} \right), \text{ it is evident,}$$

that $\frac{q^n}{n\beta} - \frac{q^n}{nb}$ can have no definite signification, unless b, β ,

and q be all expressed in terms of the same measure. As the

conveniency of computation requires that p or q^{1+n} should be expressed in fathoms, so b and β must also be expressed in parts of a fathom. The same is true of the logarithmic expression,

$\frac{n}{2} \log. b \beta$, to which the preceding one is reduced. Thus, if

$$b = 30 \text{ inches, and } \beta = 20 \text{ inches, we must make } b = \frac{5}{12},$$

and $\beta = \frac{5}{18}$, so that $b\beta = \frac{5 \times 5}{12 \times 6 \times 3}$, half the hyperbolic logarithm of which, or that of $\frac{5}{6\sqrt{6}}$, is $= -1.0782$, and this multiplied into $-n$, supposing $n = .0015$, gives $+.0016$ to be multiplied into A , or the height as already approximated. The correction here is, therefore, about $\frac{1}{637}$ of A . In other cases, it will exceed this proportion as $b\beta$ diminishes, but (because $b\beta$ will rarely be greater than $\frac{25}{144}$), its minimum will be about $\frac{1}{770}$. In the measurement of great heights, therefore, this equation may deserve to be considered.

31. We come now to find the correction which must be made on the ordinary rule, on account of the diminution of gravity as we ascend from the surface of the earth. By § 27. we have,

$$\frac{q^{1+n} \left(1 + \frac{x}{s}\right)^n}{\beta} - \frac{q^{1+n}}{b^n} =$$

$$\frac{nx}{g(H-b)} \left((1-m)^{H-r} - (1-m)^{b-r} - \frac{2x}{gs(H-b)} (1-m)^{H-r} + \right.$$

$$\left. \frac{2x}{s} (1-m)^{b-r} + \frac{2x}{gs(H-b)} (1-m)^{b-r} \right); \text{ and since we know al-}$$

$$\text{ready, that } x = \frac{\frac{1}{n} q^{1+n} g(H-b) \left(\frac{1}{\beta^n} - \frac{1}{b^n} \right)}{(1-m)^{H-r} - (1-m)^{b-r}} \text{ nearly, if we sub-}$$

stitute this value of x , or rather that which was before derived from

from it, viz. $z = q \left(1 + m \left(\frac{H+b}{2} - r \right) \right) \left(\frac{q^n}{n\beta} - \frac{q^n}{nb} \right)$, in all the

terms of this equation, into which s enters as a divisor, we shall have a new and more accurate value of z , and, by a like process, might from thence obtain one still more accurate, if it were necessary.

Now, if this be done, and if the correction depending on n be supposed sufficiently determined by the computations of the two preceding articles, so that it may now be neglected altogether; and if m also be so small, that all the powers of it, higher than the first, may be neglected, we obtain,

$$z = p \left(1 + m \left(\frac{H+b}{2} - r \right) \right) \log. \frac{b}{\beta} + \frac{2p^2}{s} \left(1 + m \left(\frac{H+b}{2} - r \right) \right)^2 \log. \frac{b}{\beta} + \frac{p^2}{s} \left(1 + m \left(\frac{H+b}{2} - r \right) \right)^2 \left(\log. \frac{b}{\beta} \right)^2.$$

32. THE first term of the preceding equation is the height corrected by M. DE LUC's method; the second term, viz. $\frac{2p^2}{s} \left(1 + m \left(\frac{H+b}{2} - r \right) \right)^2 \log. \frac{b}{\beta}$, is the correction for the diminution of the weight of the quicksilver in the uppermost barometer; and the third term, or $\frac{p^2}{s} \left(1 + m \left(\frac{H+b}{2} - r \right) \right)^2 \left(\log. \frac{b}{\beta} \right)^2$, is the correction for the gradual diminution of the weight of the air in the different strata between the lower and the upper station. The last of these two corrections, which, in all ordinary cases, is also the least, is the only one of them to which, it would seem, that any attention has hitherto been paid. The other, or the effect of the diminution of the gravity of the quicksilver, was included in this investigation, when, at § 25. we substituted for

γ its value, $\frac{\left(\frac{s'}{(s+x)}, \beta\right)^{1+n}}{q^{1+n} (1+m)^{\tau+\lambda x}}$. It is found by making as s to

$p\left(1+m\left(\frac{H+b}{2} - r\right)\right)$, so twice the height, computed by the ordinary method, to a fourth proportional, which is to be added to that height.

THE correction for the diminished gravity of the air is a third proportional to the semi-diameter of the earth, and the height, as computed by the ordinary rule. For different mountains, therefore, this correction is in the duplicate ratio of their heights.

THESE corrections are both additive, and for such a mountain as Coraçon may be equal, the first to 42, and the second to 12 feet.

33. IN the measurement of depths below the surface of the earth, β is greater than b , and $\nu = -1$, so that the compressing

force, at any depth x below the surface, is $= \left(\int \frac{s-x}{s} y \dot{x}\right)^{1+n}$,

where the fluent is affirmative, not negative, as in all the preceding instances, because the air which, by its weight, compresses the stratum at the depth x , is on the same side of that stratum with x , whereas it was before on the opposite side.

Making, therefore, $y = \frac{+ \left(\int \frac{s-x}{x} y \dot{x}\right)^{1+n}}{p(1-m)^{\tau+\lambda x}}$, we have,

by proceeding as above,

$$z = p\left(1+m\left(\frac{H+b}{2} - r\right)\right) \log. \frac{\beta}{b} - \frac{p^2}{s} \left(1+m\left(\frac{H+b}{2} - r\right)\right) \log. \frac{\beta}{b} \\ + \frac{p^2}{2s} \left(1+m\left(\frac{H+b}{2} - r\right)\right)^2 \left(\log. \frac{\beta}{b}\right)^2.$$

In

In this formula, the second term, *viz.* — $\frac{p^2}{s} \left(1 + m \left(\frac{H+b}{2} - r \right) \right) \log. \frac{\beta}{b}$ is just half the corresponding term in the preceding formula, (§ 31.) with a contrary sign, so that the correction for the diminution of the gravity of the quicksilver takes away from a depth, as it adds to an elevation. The correction

$\frac{p^2}{2s} \left(1 + m \left(\frac{H+b}{2} - r \right) \right)^2 \left(\log. \frac{\beta}{b} \right)^2$ retains the same sign in both cases, but in this is only half of what it was in the former. That these last corrections should be each half of the corresponding one in the preceding case, might have been concluded from this, that, by any small ascent above the surface of the earth, the force of gravity is twice as much diminished as by an equal descent below it. The reason of the change of the signs in the second term is also sufficiently obvious.

34. THOUGH these corrections suppose that z is small in respect of s , yet they would afford a sufficient approximation to the truth, were we to reason concerning much greater depths under the surface of the earth than any to which man can penetrate. For example, on a supposition that the atmosphere was continued downwards within the earth, its density being always as its compression, and its temperature every where the same, (and, for the greater ease of computation equal to r), let it be required to find, at what depth its density would become equal to that of mercury. To resolve this problem, it must be remembered, that the density of mercury, throughout all this computation, has been supposed = 1, and p equal to the height of a column of mercury, which, gravitating every where with the same force as at the surface, would, by its pressure, give to air the density 1. If a barometer, therefore, were carried down to the depth at which air was as dense as mercury, the mercury in it would rise to the height p , or to 4343 fathoms nearly, supposing, at the same time, that its own gravity were not diminished. Now, on this supposition, (by § 33.)
any

any depression below the surface, as, $z = p \log. \frac{\beta}{b} + \frac{p^2}{2s} \left(\log. \frac{\beta}{b} \right)^2$, the temperature being supposed $= r$, and the term $-\frac{p^2}{s} \log. \frac{\beta}{b}$ being left out, as relating only to the diminution of the weight of the quicksilver in the lower barometer. If, then, b , or the column of mercury in the barometer at the surface, be 30 inches, or $\frac{5}{12}$ of a fathom, and $\beta = 4343$, we find $p \log. \frac{\beta}{b} = 10000 \times \text{tabular log. } 10423 = 40180 \text{ fathoms} = 45.6 \text{ miles nearly}$. The second term, $\frac{p^2}{2s} \left(\log. \frac{\beta}{b} \right)^2$, (or the square of the former divided by the diameter of the earth), $= +.25$ of a mile, so that $z = 45.85$ miles nearly. The approximation might be carried to much greater exactness if it were necessary; but this is sufficient to shew, that, at a less depth under the surface than 46 miles, the density of air would become equal to that of quicksilver; and if this conclusion appear, in any degree, paradoxical, it need only be considered, that, abstracting from any diminution of the power of gravitation, the density of air would be nearly doubled by every $3\frac{1}{2}$ miles of descent below the surface of the earth.

35. IF, again, we would form any conclusion concerning the limit to which our atmosphere may extend upwards, we must

$$\text{resume the formula, } y = \frac{\left(-\int \frac{s^y}{(s+x)^y} yx \right)^{1+n}}{q^{1+n} (1-m)^{1+\lambda x}} ;$$

and, if we would abstract from the effect of the cold in the higher regions to reduce the atmosphere within narrower limits than those to which it would otherwise extend, we

we may suppose the temperature $r+f$ to be uniformly diffused through it, and so for $(1-m)^{r+\lambda x}$ we may substitute $1+fm$. Putting also $a = q(1+fm)^{\frac{1}{1+n}}$, and making $s+x$, or the distance from the centre, $=v$, $ay^{\frac{1}{1+n}} = -\int s^v v^{-v} y \dot{v}$; wherefore, taking the fluxions, dividing by y , and integrating,

$$-\frac{a}{n}y^{-\frac{n}{1+n}} + C = (v-1)s^v v^{1-v}.$$

To define C , suppose that $y = D$ when $x = 0$, or when $v = s$;

$$\text{then, } C = \frac{a}{n}D^{-\frac{n}{1+n}} + (v-1)s; \text{ and so,}$$

$$\frac{a}{n}\left(D^{-\frac{n}{1+n}} - y^{-\frac{n}{1+n}}\right) = (v-1)(s^v v^{1-v} - s);$$

$$\text{and making } v = 2, \quad \frac{a}{n}\left(D^{-\frac{n}{1+n}} - y^{-\frac{n}{1+n}}\right) = s\left(\frac{s}{v} - 1\right).$$

36. Now, if n be affirmative, as has been supposed, this formula, because of the negative exponent of y , gives s infinite, when $y = 0$. The atmosphere, therefore, on this supposition, admits of no limit. But, if we suppose n to be negative, that is, if we suppose the density to be as the power $1-n$ of the compression, instead of $1+n$, the formula of the last article becomes

$$\frac{a}{n}\left(D^{\frac{n}{1-n}} - y^{\frac{n}{1-n}}\right) = s\left(1 - \frac{s}{v}\right).$$

Q

And

And if we now suppose the atmosphere to terminate, or y to

become $= 0$, then $\frac{aD^{\frac{n}{1-n}}}{n} = s(1 - \frac{s}{v})$, and the entire height of the atmosphere, or $v = \frac{s^2}{s - \frac{a}{n}D^{\frac{n}{1-n}}}$.

THIS value of v may either be finite, infinite, or negative, according to the different magnitudes assigned to n and D . If

these be such that s is equal to $\frac{a}{n}D^{\frac{n}{1-n}}$, it is obvious that v is

infinite; but if s be greater than $\frac{a}{n}D^{\frac{n}{1-n}}$, v must be finite

and affirmative. If s be less than $\frac{a}{n}D^{\frac{n}{1-n}}$, then v is negative;

by which we are to understand, that the height of the atmosphere is, as it were, more than infinite, or that its density is finite, even at an infinite distance. It must be remarked, too, that, when n is very small, as it must be in the case of the

earth's atmosphere, $D^{\frac{n}{1-n}}$ being nearly $= 1$, we have $v = \frac{s^2}{s - \frac{a}{n}}$.

As $a = 4343$ fathoms, (on the supposition that the temperature of the atmosphere is 32°), and as $s = 3491840$, it follows, from this formula, that, according as n is greater than .00125, equal to it, or less, the density of the atmosphere will vanish at a finite, an infinite, or not even at an infinite distance.

37. BUT to return to what is the more immediate object of this paper, it will now be proper to bring into one view the

the different corrections that have been investigated. We must, therefore, recollect, that the coefficient p is the length of a column of mercury, which, pressing on air of the temperature r , would give to it the density of mercury, (which is denoted by unity), supposing, at the same time, that the density of air is as the force compressing it. Hence p is likewise the height of a homogeneous column of air, of any density whatever, which, by its pressure, would make air of the same density with itself; or it is the height to which the atmosphere would extend above the surface of the earth, if it were reduced to the same density throughout, which it has at the surface of the earth, when it is of the temperature r . It has been found by experiment, that, when $r = 32^\circ$, p is nearly equal to 4342.9448 fathoms, which number is the modulus of the tabular logarithms multiplied by 10000. This determination, however, is only to be considered as approaching to the truth, if we are to have regard to the following corrections. Instead of p , in some of these investigations, we have used q to denote the height of a column of mercury, which, supposing the condensation of air to be as the power $1+n$ of the compressing force, would, by its pressure, give to air the density of mercury, or the density 1; q^{1+n} cannot differ much from p , but its precise length is to be determined only by experiment. In what follows, p is put for the numeral coefficient, whatever it may be, by which the formula must be multiplied to give the height in fathoms, or in any known measure.

THE expansion of air for one degree of heat, the temperature being 32° , and the height of the barometer 29.5 inches, is $= m = .00245$ nearly. μ is the exponent of a power such that

29.5 being denoted by γ , $\frac{\beta^\mu}{\gamma^\mu} \times m =$ the expansion for one

degree of heat, when the mercury in the barometer stands at β . The value of μ is not certainly known; it is probably be-

tween 1 and $\frac{1}{3}$. n is a number such, that the density of air is as the power $1+n$ of the compressing force; it is supposed $= .0015$.

THE heights of the mercury in the barometers, at the lower and upper stations, are b and β ; H and h are the temperatures, marked by FAHRENHEIT'S thermometer at those stations respectively, and $\frac{H+b}{2} - r$ is put $= f$.

39. THEN, the first approximation to the height, without any correction, is, $z = p \log. \frac{b}{\beta}$.

1^{mo}. The first correction, M. DE LUC'S, (§ 17.)

$$+m \left(\frac{H+b}{2} - r \right) p \log. \frac{b}{\beta}.$$

2^{do}. THE correction for the decrease of heat in the superior strata of the atmosphere, and for the first inequality of expansion, (§ 19.) =

$$+m^2 \left(\frac{r}{2} - \frac{H+b}{4} + \frac{r(r-H-b)}{2} + \frac{H^2+4Hb+b^2}{12} \right) p \log. \frac{b}{\beta}.$$

3^{tio}. THE correction for the second inequality of expansion, or for its variation by a given change of temperature, according

to the pressure, (§ 22.) = $+ \frac{\mu m}{2} \left(\frac{H+b}{2} - r \right) p \log. \frac{b}{\beta} \times \log. \frac{b\beta}{\gamma^2}$;

or, if E be put for M. DE LUC'S, or the first equation, this last = $+ \frac{\mu E}{2} \log. \frac{b\beta}{\gamma^2}$. But as μ does not appear to be very small,

it will be more accurate to compute $\frac{p f m (b^\mu - \beta^\mu)}{\mu \gamma^\mu}$, which includes in it both the first and third corrections (§ 21.).

4^{to}.

4to. THE correction on account of the departure of the law of the elasticity of air, from that of the direct ratio of the density, (§ 29.) = $-\frac{n}{2}p\left(1+m\left(\frac{H+b}{2}-r\right)\right)\log.\frac{b}{\beta}\times\log.b\beta$. In this equation, b and β must be expressed in the same measure with p , that is, in fathoms.

5to. FOR the diminution of the weight of the quicksilver in the upper barometer, there is an equation to be applied =

$$+\frac{2p^2}{s}\left(1+m\left(\frac{H+b}{2}-r\right)\right)^2\log.\frac{b}{\beta}.$$

6to. ON account of the diminished gravity of the air in ascending from the surface of the earth, there is a sixth correction = $+\frac{p^2}{s}\left(1+m\left(\frac{H+b}{2}-r\right)\right)^2\left(\log.\frac{b}{\beta}\right)^2$.

WHEN a depth below the surface is to be measured, the fifth equation becomes negative and loses the multiplier 2 ; the sixth remains affirmative, but is divided by 2.

40. THESE equations, even exclusive of the first, may, in the measurement of great heights, amount to a considerable proportion of the whole. In the instance of Coraçon, 15833 feet above the level of the sea, the greatest height to which the barometer has ever been carried, the first equation exceeds 1100 feet, and the third appears not to be less than — 300. The remaining corrections are, indeed, less considerable ; but, being all affirmative, they must not be entirely neglected. And, on the whole, it is certain, that, though the first equation alone will give the height sufficiently exact, while it does not exceed five or six thousand feet, yet, at greater elevations, the corrections that have now been enumerated must all be taken into account. To facilitate the computation by means of them, they ought to be reduced into tables adjusted to their proper arguments, after the values of p , m and r are accurately determined,

mined, by comparing the formula that has been given here with observations. But this would lead into disquisitions far exceeding the bounds of the present inquiry, the object of which is, to ascertain the form, rather than the absolute quantity of these corrections.

41. IT is evident, that, in the preceding investigation, as well as in all the other methods of measuring heights by the barometer, it is supposed, either that the one of the barometers is vertical to the other, or that a perfect æquilibrium prevails through that part of the atmosphere intercepted between them. The determination of the constant quantity in the foregoing integrations, by supposing that $b = \beta$ when $x = 0$, or that the mercury in the two barometers stands at the same height in them, when they are at the same distance from the surface of the earth, obviously involves in it either the one or the other of these conditions. But the last of them, the æquilibrium of the atmosphere, never takes place; and, therefore, it is necessary, in order that barometrical measurements be perfectly accurate, that the one barometer be immediately above the other, or, at least, that the horizontal distance between them be very small. If this be not the case, the unequal distribution of the heat through the different parts of the same stratum of air will render it impossible to deduce the difference of the heights of the barometers from a comparison of the columns of mercury contained in them.

FOR instance, let there be three barometers; the *first* at the surface of the earth, the *second* raised up into the air perpendicularly above the *first*, and the *third* removed into a colder climate, but raised up also into the air, so as to have in it a column of mercury of the same length with that in the *second*. These two last, when compared together by M. DE LUC's, or by the preceding rules, will appear to be at the same height above the surface, or above the first barometer. But, if each of them be compared with the *first*, the *second* will appear
more

more elevated above it than the *third*, because of the greater cold supposed to prevail in the region where this last barometer is placed. Here, therefore, are two different determinations of the height of the third station above the first, neither of which has any claim to be preferred to the other. It is evident, therefore, that, in barometrical measurements, there is always a degree of uncertainty introduced by the horizontal distance between the two stations, and that, beside those accidental errors, which are of the less consequence, that, in a number of observations, they may nearly compensate for one another.

It must be confessed, too, that we have not at present the means of removing this uncertainty, nor even of ascertaining its limits with tolerable exactness. These depend on a problem which is no longer to be resolved by the principles of statics, but requires the *motions* of an elastic fluid, under various degrees of compression and rarefaction, to be determined. The solution, therefore, is extremely difficult; and no result, sufficiently simple to be of use in these computations, is ever likely to be obtained from it.

It would, however, be of consequence to determine, by observation, the mean height of the barometer at the level of the sea in the different regions of the earth. That mean height is not every where the same. Under the line, it appears, from the observations of M. BOUGUER, to be 29.852 inches, reducing the mercury to the temperature of 55° ; and in Britain, it is 30.04, reducing the mercury to the same temperature. The mean temperature of the air, as well as its mean weight in different climates, will also require to be determined before the art of levelling extensive tracts by the barometer can be brought to perfection.

42. THERE is another cause of error which, had the effects of it been sufficiently known, ought, no doubt, to have entered into this investigation. Moisture, when chemically united to air, or dissolved in it, so as to compose a part of the same homogeneous

homogeneous and invifible fluid, appears to have a powerful effect to encrease the elasticity of the air, and its expansion for every additional degree of heat which it receives. In experiments with the manometer*, it has been observed, that, till the moisture was diffolved in the air, it had no fenfible effect on its elasticity; but that, as foon as it began to diffolve, the expansion, for one degree of heat, was encreased, and continued to be fo, for every fucceffive addition of heat, from thence to the boiling point, where it became nine times that of dry air. From this, too, it probably proceeded, that, at Spitzbergen, within ten degrees of the pole, a place where the circle of perpetual congelation in the atmofphere, approaches near to the furface of the earth, and where the air may naturally be fupposed to be very dry, the ufual rule for the meafurement of heights was found to err greatly in excefs, and it appeared, that the density of the air was greater than could have been inferred from its compreffion and its temperature.

43. THOUGH the judicious and accurate experiments of General ROY have afcertained this effect of humidity, and have even gone far to determine the law of its operation, yet, for want of a meafure of the quantity of it, contained, at any given time, in the air, it is impoffible to make any application of this knowledge to the object under our confideration. While I was reflecting on this difficulty, it occurred, that the barometer itfelf might become a meafure of the humidity of the air, and that the error committed in the meafuring of a known height, if all other circumftances were taken in, would determine the quantity of that humidity. For, if we fuppose, that the formula $z = p \left(1 + m \left(\frac{H+b}{2} - r \right) \right) \log \frac{b}{\beta}$ gives the true height between the ftations at which two barometers have been obferved, when the moisture diffolved in the air is of its medium quantity, (which we may call unity), then, if that

moifture

* See General ROY's experiments, fection 2. Phil. Tranf. vol. 67. part 2.

moisture be either increased or diminished, the expression $p \left(1 + m \left(\frac{H+b}{2} - r \right) \right) \log. \frac{b}{\beta}$ will no longer be equal to the true height, but must be multiplied into $1 \pm \pi$ in order that it may be equal to z . Now, this fraction $\pm \pi$ represents the excess or defect of the moisture dissolved in the air above or below its mean quantity; or, more exactly, it is proportional to the increase or diminution of the elasticity of the air arising from that cause. When $p \left(1 + m \left(\frac{H+b}{2} - r \right) \right) \log. \frac{b}{\beta}$ is less than the true height, the fraction π must be affirmative, and indicates an increase of elasticity, and, consequently, of moisture in the air.

The contrary happens when $p \left(1 + m \left(\frac{H+b}{2} - r \right) \right) \log. \frac{b}{\beta}$ is greater than the true height. To determine π , since $z = (1 + \pi) p \left(1 + m \left(\frac{H+b}{2} - r \right) \right) \log. \frac{b}{\beta}$, $1 + \pi = \frac{z}{p \left(1 + m \left(\frac{H+b}{2} - r \right) \right) \log. \frac{b}{\beta}}$.

Or if the error, that is $z - p \left(1 + m \left(\frac{H+b}{2} - r \right) \right) \log. \frac{b}{\beta} = e$,

$$\text{then } \pi = \frac{+e}{p \left(1 + m \left(\frac{H+b}{2} - r \right) \right) \log. \frac{b}{\beta}}, \text{ or } \pi = \frac{+e}{z - e}.$$

44. To apply the barometer, therefore, for the purposes of hygrometry, let there be two barometers fixed, the one at the top, and the other at the bottom of a high tower, or hill of moderate elevation, and let them be observed at the same instant, together with their corresponding thermometers. If the difference of their heights, computed from thence, be equal precisely to the true difference, then is the moisture dissolved in the air no way different from its mean quantity; but if the difference of the heights so computed be greater or less than the truth, then π , as above determined, will give the quantity by which the actual moisture in the air is less or greater than the mean quantity. The height at which the one barometer should be placed above the other, ought not to be so small that

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the unavoidable errors of observation, (which may amount to five feet), may be considerable in respect of the whole; nor so great as to introduce error from other causes. It ought not, therefore, to be less than 100, nor much greater than 500 feet.

45. IN this manner, we shall have a measure, not indeed of the absolute quantity of humidity dissolved in the air at a given time, but of the differences of the humidity dissolved in it at different times. Our hygrometer, therefore, will afford a scale for the measuring of moisture, not unlike that which the thermometer affords for the measuring of heat; and both deduced from the changes produced on the bulk, or the specific gravity of certain bodies. The beginning, or zero, of this scale may also be fixed by a certain and invariable rule, if we assume m , in the preceding formula, (or the expansion of air for one degree of heat), of a given magnitude, as, for instance, .00245, and conceive the scale to begin when $\pi = 0$, or when the formula, thus adjusted, gives the true height.

THE hygrometer with which we will be thus furnished, seems well adapted to the purposes of astronomy. For it measures the humidity chemically united with the air, and not merely the disposition of the air to deposit that humidity, which, though much connected with the changes of the weather, has little to do with the astronomical refraction. It is true, that the fractions π may not be directly proportional to the differences of the humidity of the air, nor to the changes of refracting power, which those differences of humidity may produce; but they are probably connected with these last, by some fixed and invariable law, which future experiments may be able to ascertain. Nor can this application of the barometer fail of leading to some useful conclusion; for if, on trial, it shall be found, that the operation of humidity in changing the specific gravity of the air, is over-ruled or concealed by the action of more powerful causes, the discovery, even of this fact, will give a value to the observations.

IV. *On the USE of NEGATIVE QUANTITIES in the SOLUTION of PROBLEMS by ALGEBRAIC EQUATIONS.*
By WILLIAM GREENFIELD, M. A. F. R. S. EDIN. Minister of St Andrew's Church, and Professor of Rhetoric in the University, of EDINBURGH.

[*Read by the Author, April 12. 1784.*]

BY the introduction of letters into algebra, to denote all the quantities, both known and unknown, involved in an equation, this very important advantage was gained, that the final equation exhibited both a general rule for the solution of all similar problems, and also the limitations within which such problems were possible.

THIS, however, could not be understood universally, if the signs + and — were not used in that extensive sense in which they are now taken. For there are innumerable problems, which require us to consider some of the quantities, as capable of existing in two opposite situations. Thus the distance of a star from the horizon, may include both its elevation at one time, and its depression at another. Hence, in the general investigation of this distance, two different cases arise, which may seem to require two different equations.

MATHEMATICIANS, however, came naturally to consider such opposite situations as analogous to addition and subtraction. And, upon this ground, they made the equation to which the problem was reduced in the one case, serve also for the other, in the following manner: If it was one of the unknown quantities which had changed its situation, they took a negative root; if it was one of the known quantities, they

changed its sign in the equation. It is evident how vast an accession was thus gained to the elegance and universality of algebraical solutions.

ALBERT GIRARD appears to have been the first who observed this use of negative roots. In his work, published in the year 1629, entitled, *Invention nouvelle en Algebre*, he mentions it with great distinctness, and as a matter unknown before *.

MONTUCLA, who acknowledges that he never saw the work of GIRARD, insists very strenuously that DES CARTES was the person, to whom we owe our knowledge of the nature and use of negative roots; that it was he, who first introduced them into geometry and algebra †. But without derogating from the very extraordinary merit of that philosopher, we must beg leave, in this matter, to differ somewhat from MONTUCLA. For, according to his own account, the work of GIRARD was published in 1629, whereas the *Geometry* of DES CARTES was not published till seven or eight years afterwards, in 1637 ‡.

WE may, perhaps, go farther, and add, that although DES CARTES indeed observed, that the shifting of a line or point from one side of a given line or point to the other, made no change in the equation, except in the signs + and —, yet he did not see, in its full extent, all the advantage to be derived from the use of negative quantities. This will appear not altogether improbable from the following circumstances: In the third book

* I HAVE not been able to procure the book; but the following passage, quoted by Dr HORSELEY, seems to warrant what has been asserted: "Jusques icy nous n'avons encore expliqué à quoy servent les solutions par moins, quand il y en a. La solution par moins s'explique en geometrie en retrogradant, et le moins recule là où le + avance." And, after giving an instance, he adds; "Et ainsi faudra-t-il entendre de toutes solutions par moins; qui est une chose de consequence en geometrie incognue auparavant." HORSELEY'S NEWTON, vol. 1. p. 171. note (u).

† MONTUCLA Hist. de Math. vol. 2. p. 85.

‡ MONTUCLA Hist. de Math. vol. 2. p. 82. & 84.

book of his *Geometry*, where he treats expressly of the nature of equations, he takes no notice of those which have all their roots negative; and, in the second book, where he mentions his new method of considering curves, he says nothing of negative abscissæ and ordinates, although the analysis of curves is, of all the parts of mathematics, that which most obviously suggests and requires the use of the negative roots.

IN fact, the use of negative quantities appears not to have been, either at this time, or for some time afterwards, familiar to mathematicians. This is evident from the *Elementa Curvarum* of JOHN DE WITT, a work, at that time, of some merit, but which will be considered, rather as affording a curious piece of information in the life of that great man, than as adding to a fame, which is so far superior to all literary eminence. In this work, which is published by SCHOOTEN at the end of his edition of DES CARTES'S *Geometry*, no notice is taken of negative abscissæ and ordinates: So that the author is obliged to consider separately two or more equations, which every mathematician at present, from the view of negative quantities, which is now become familiar, would consider as one single equation, denoting for one and the same line referred to the same axis, the relation between the abscissæ and ordinates, through all the different cases of their situation with respect to each other, that is, through all the angles of the coordinates. Thus, in his second book, where he considers the lines of the first and second order, beyond which he does not go, he demonstrates, in the four first theorems, that the four following equations belong to straight lines: 1. $y = \frac{bx}{a}$;

2. $y = \frac{bx}{a} + c$; 3. $y = \frac{bx}{a} - c$; 4. $y = -\frac{bx}{a} + c$. But he does not show, either in this or any other part of the work, that each of these equations, by changing the signs of y or x , gives the relation between the absciss and ordinate, when the one or the

the other is taken in an opposite situation; and that the second and fourth equation ought to be considered as one, and as belonging to the same straight line referred to the same axis.

EVEN long after this time, we find, that Dr WALLIS, although, in his *Algebra*, he considers at some length the meaning and use of negative quantities, yet, in his *Arithmetic of Infinites*, falls into a strange mistake, which leads us to suspect, that his notions on this subject were not perfectly clear. For, observing that his general expression for hyperbolic areas would, in certain cases, be a fraction with a negative denominator, he did not perceive, that this expressed the area on the other side of the ordinate, instead of the area sought; but he contents himself with saying, that the denominator of the fraction being less than nothing, denoted the area to be more than infinite.

THAT even some time afterwards, the use of negative quantities had not become familiar, appears from the astonishment which Dr HALLEY expresses at his own discovery of a formula, which, by the mere change of the signs, gave the focus both of converging and diverging rays, whether reflected or refracted by convex or concave specula or lenses. And Mr MOLYNEUX speaks of the universality of HALLEY's formula as somewhat that resembled magic.

THUS it appears to have been long, before mathematicians ventured to employ negative quantities so freely, as we now perceive them to be employed. The reason of which probably was, that no satisfactory account had been given of the grounds upon which the conclusions drawn from them are founded. But the consistency of these conclusions, with all the most indisputable truths of the mathematical sciences, and the great beauty and advantage, derived from the very general solutions which are thus obtained, gradually established their use.

STILL, however, a complaint remains, which appears to be too well founded, that the Method of negative quantities, as has been the case with some other rules of the art, is supported,

ed, rather by induction and analogy, than by mathematical demonstration. But something more than this is to be expected from mathematicians; and their knowledge of algebra will still be considered as imperfect, if there be any of its operations which they cannot, in every letter and sign of it, explain as a series of just reasoning, capable of being expressed in common language. Now, it does not appear that our instructors in mathematics have enabled us to do this in the cases to which we allude, that is, where negative quantities are found, without any intimation of the quantities from which they are subtracted. In considering the abstract operations of addition, subtraction, multiplication, &c. we may indeed take negative quantities by themselves: For here the meaning is obvious; we are examining, in what manner such operations will affect those quantities, which are subtracted from other quantities. But when we come to apply these operations to the business of algebra, the resolution of equations, it is not so easy to perceive, nor does it appear to have been sufficiently explained, in what light we are to consider negative quantities, or how mathematicians are to be justified in the use which they make of them. The very vague and unsatisfactory, and often mysterious accounts of the matter, which are given even by writers of the greatest eminence, serve only to shew, that although they are satisfied of the certainty of the method, yet they perceive that something still remains which ought to be explained, and of which no good explanation has been given.

Mr Baron MASERES, indeed, has published a large work, which he entitles, "A Dissertation, on the use of the negative sign in algebra; containing a demonstration of the rules usually given concerning it, and shewing how quadratic and cubic equations may be explained, without the consideration of negative roots." But this dissertation contributes little to remove the difficulties complained of. For even allowing the author to be right in his notion, that it would be better "if negative

“ gative roots had never been admitted into algebra, or were
“ again discarded from it * ;” yet still he has carried us to the
length only of cubic equations. The truth is, that the whole
business of algebra might be carried on without the considera-
tion of the negative roots. The difference between such a system
and the present, is precisely this ; that wherever a problem re-
quired us to consider any of the quantities, as existing in oppo-
site situations ; wherever, for instance, a line or a point was to be
considered, as situated first on the right hand, and then on the
left ; it would be necessary, to find and to resolve a separate equa-
tion for each of these cases. Thus, in the analysis of any par-
ticular curve, it would be necessary to have a separate equation
for each of the four angles of the co-ordinates ; except, indeed,
the axes were so chosen, as to make us certain that there were
some of these angles, in which no part of the curve was to be
found. Since, therefore, the use of negative quantities frees us
from this inconvenience, which, in many cases, particularly in
the analysis of curves, would be exceedingly perplexing ; and
since it evidently affords so great elegance and universality to
algebraical solutions ; to find our author gravely declaring that
he can see no advantage in it, is perfectly astonishing : As it is
to be lamented, that he did not exert his industry and ingenui-
ty, rather to confirm than to destroy ; rather to demonstrate, how
far we might rely on the method of negative quantities, than
to overturn at once so great a part of the labours of the modern
algebraists.

WHAT follows is an attempt to explain this subject, without
considering the negative sign in any other light, than as the sign
of subtraction ; and without proposing any alteration in the
received system of algebra.

* Dissert. on the Neg. Sign, p. 34.

I. Of the Negative Roots of Equations.

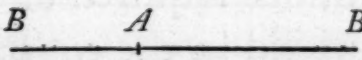
1. Of Determinate Equations.

IN the solution of problems by means of equations, the analyst fixes upon one or more quantities, by the determination of which all that is required may be known or performed. We shall at present suppose that there is only one quantity to be determined. The problem shews the conditions which are required of this quantity; and these conditions, as far as they can be so expressed, are reduced to an equation of the common form,

$$L \dots a + bx + cx^2 + \mathcal{E}c. = 0.$$

Here, according to the common method in the general notation of equations, the sign + denotes, at pleasure, either the addition or subtraction of the terms to which it is prefixed.

IN many cases, nothing else is required, but to determine the *magnitude* of the quantity sought. There the positive roots alone can determine the magnitude; so that if the equation has no positive roots, or none which come within the limits of the problem, then the problem is impossible.

BUT let the problem require us to determine, not only the different magnitudes of the line AB (x), but also, with respect to each of these  magnitudes, whether it lies on the right or left of the given point A . Here we suppose the problem to be such, that whether we reduce it to an equation, upon the supposition that AB lies to the right, or upon the supposition that it lies to the left, there is no circumstance, except only the opposite situation of AB , to make any difference in these equations.

IN this case, we make either supposition at pleasure; as, for instance, that it lies to the right; and, on this supposition,
S we

we express the conditions required of AB in an equation, as,

$$L \dots a + bx + cx^2 + \mathfrak{E}c. = 0.$$

Then, in determining the magnitude of AB in this direction, the positive roots are to be employed.

Now, on the other side of A , take MA , which we shall denote by X ; and let it be of any magnitude, not less than any of $\frac{M}{B}$ $\frac{B}{A}$ $\frac{A}{B}$ the negative roots of L . It is evident that L may be reduced to the form

$$M \dots \left\{ \begin{array}{l} + \frac{A}{BX} + Bx \\ + CX^2 + 2CXx + Cx^2 \\ + \mathfrak{E}c. \end{array} \right\} = 0.$$

And this again may be reduced to the form

$$N \dots A + B(X+x) + C(X+x)^2 + \mathfrak{E}c. = 0.$$

THE equation N , therefore, is another expression of the conditions required of x , upon the supposition that it lies to the right of A .

BUT if we make the contrary supposition, that AB lies to the left of A ; then since this is the only alteration in the conditions which the equation N requires of x ; therefore, the conditions required of it, when it lies to the left of A , will be expressed in the equation

$$N' \dots A + B(X-x) + C(X-x)^2 + \mathfrak{E}c. = 0.$$

Now, this equation may be reduced to the form

$$M' \dots \left\{ \begin{array}{l} + \frac{A}{BX} - Bx \\ + CX^2 - 2CXx + Cx^2 \\ + \mathfrak{E}c. \end{array} \right\} = 0.$$

By

By comparing this equation with M and L , it will be evident that it may be reduced to the form

$$L' \dots a - bx + cx^2 - \mathcal{E}c = 0.$$

THIS equation L' , therefore, expresses the conditions required of AB , when it lies to the left of A ; and, consequently, the positive roots of L' determine the different magnitudes of AB in that situation.

BUT L' differs from L , only by having changed the signs of the terms involving the odd powers of x . Therefore L and L' have the same roots, except only that the positive roots of the one are the negative roots of the other.

THEREFORE, the negative roots of the equation L , to which the problem is reduced, upon the supposition that AB lies to the right of A , are the positive roots of the equation to which it would be reduced, upon the supposition that AB lies to the left of A . Therefore, these negative roots are the determinations of AB in this last situation.

AGAIN: Let it be required to determine, not only the *distance* of time between a certain event and a given instant; but also, whether the event happened *after* or *before* the given instant. Then reduce the problem to an equation, L , upon either supposition, as, for instance, that it happened after; and by assuming X , a period of time immediately before the given instant, we can shew, as above, that the negative roots of L will be the determination of the epoch, when it happened before the given instant.

IN like manner, let it be required to determine, not only the *momentum* of the force which acts in the right line AB , but also, whether it acts in the *direction* AB , $\overset{A}{\rule{1.5cm}{0.4pt}}\overset{B}$ or in the direction BA . Then, if we reduce the problem to an equation, upon the supposition that it acts in the direction AB , we are to assume X , an additional force acting in the same direction.

IN like manner, let it be required to determine, not only the *value* of a certain sum of money, but also, whether it is part of a certain person's *stock*, or whether it is part of his *debts*. Then, if we reduce the problem to an equation, upon the supposition that it is part of his stock; we are to assume X a supposed additional quantity of stock.

THERE are cases, therefore, where the quantity sought is to be considered in two different situations, which may be represented by addition and subtraction from another assignable quantity of the same kind; and where there is nothing in the problem, except only this opposite situation, which can produce any difference in the equations to which it is reducible upon each supposition. From the preceding observations it will appear what may be understood by the negative roots, and how mathematicians are justified in the conclusions which they draw from them in such cases.

THE negative roots are sometimes also useful in the solution of problems relating to abstract quantities. For the equation

$$L \dots a + bx + cx^2 + \mathcal{E}c. = 0$$

has the same roots with the equation

$$L' \dots a - bx + cx^2 - \mathcal{E}c. = 0,$$

except only that the negative roots of the one are the positive roots of the other. Wherever, therefore, any problem producing the equation L , is so connected with any other problem producing the equation L' , that they may be considered as different cases of the same problem, or that the consideration of the one suggests the other; there it is evident, that the negative roots will be useful, by affording, from either of these equations, the solution of both problems. Thus, the equation $x^2 + x = a$, gives us, not only the number, which, added to its square, makes a sum equal to a ; but also, by the negative root, the

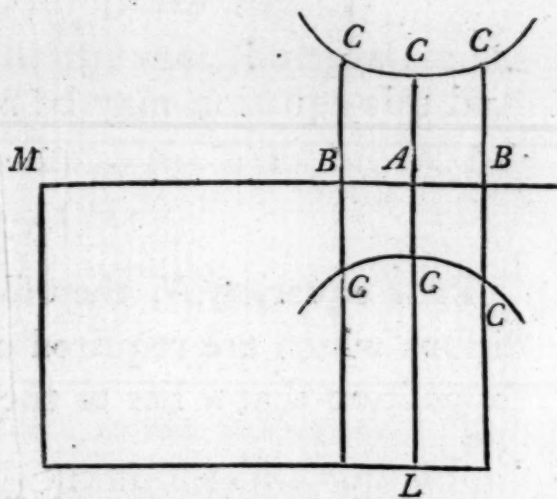
the number which, subtracted from its square, leaves a remainder equal to a .

WHAT has been said is easily applicable to those problems, where more than one quantity is to be determined.

2. Of Indeterminate Equations.

IN problems which are solved by indeterminate equations, there is often nothing else required, but to determine the different *magnitudes* of one or more of the variable quantities, corresponding to any given magnitudes of the remaining variable quantities. There the positive roots alone can determine these corresponding magnitudes; so that if there be no positive roots, or none which come within the limits of the problem, then the problem is impossible.

BUT let the problem require us to determine, not only the different corresponding magnitudes of the lines AB (x) and BC (y); but also, with respect to each of the values of x , whether it lies to the *right* or *left* of the given point A ; and with respect to each of the corresponding values of y , whether it is to be taken *above* or *below* the line AB . Here we suppose that, whether AB lies to the right or left, and whether the corresponding line BC is to be taken



upwards or downwards, there is nothing, except only these opposite situations of AB and BC , to make any difference in the equations, to which the problem would be reduced upon each of these suppositions. Then, we make any of these suppositions at pleasure; as for instance, that AB lies to the right, and that BC lies above AB ; and on this supposition, we express the conditions.

ditions required of these quantities in an equation of the common form, as,

$$L \dots a + bx + cy + dx^2 + exy + fy^2 + \mathfrak{E}c. = 0.$$

Then, in determining the corresponding magnitudes of AB and BC in these directions, the positive roots are to be employed.

Now, on the other side of A , in the line AB , take MA , which we shall denote by X , not less than any of the negative values of x ; and in the line AC , below AB , take AL , which we shall denote by Y , not less than any of the negative values of y . It is evident, that the equation L may be reduced to the form

$$M \dots \left\{ \begin{array}{l} A \\ + BX + Bx \\ + CY + \dots + Cy \\ + DX^2 + 2DXx + \dots + Dx^2 \\ + EXY + EXx + EXy + \dots + Exy \\ + FY^2 + \dots + 2FYy + \dots + \dots + Fy^2 \\ + \mathfrak{E}c. \end{array} \right\} = 0.$$

And this equation may be reduced to the form

$$N \dots A + B(X+x) + C(Y+y) + D(X+x)^2 + E(X+x)(Y+y) + F(Y+y)^2 + \mathfrak{E}c. = 0.$$

THIS equation N , therefore, is another expression of the conditions which are required of the variable quantities, upon the supposition that x lies to the right of A , and that y lies above AB .

BUT if we make the supposition that x lies still to the right of A , but that y lies below AB ; then, since this is the only alteration in the conditions which the equation N requires of x and y ; therefore the conditions required of them, upon this new supposition, will be expressed in the equation

$$N' \dots A + B(X+x) + C(Y-y) + D(X+x)^2 + E(X+x)(Y-y) + F(Y-y)^2 + \mathfrak{E}c. = 0.$$

Now,

Now, by reducing this equation to the form of M , and comparing it with L , it will be evident, that it is the same with the following equation ;

$$L' \dots a + bx - cy + dx^2 - exy + fy^2 + \&c. = 0.$$

THIS equation L' , therefore, expresses the conditions required of the variable quantities, when x lies to the right of A , and when y lies below AB . And, consequently, the corresponding positive roots of L' are the determinations of the corresponding magnitudes of AB and BC in this situation.

BUT L' differs from L , only by having changed the signs of the terms involving the odd powers of y . Therefore, L' and L have the same roots, except only that the positive values of y in the one, are its negative values in the other.

THEREFORE, in the equation L , the positive values of x , and the corresponding negative values of y , are the determinations of the corresponding magnitudes of AB and BC , when AB lies to the right of A , and when BC lies below AB .

IN the same manner, it may be shewn, that the negative values of x , and the corresponding positive values of y , are the determinations of AB , BC , when AB lies to the left, and BC lies above AB .

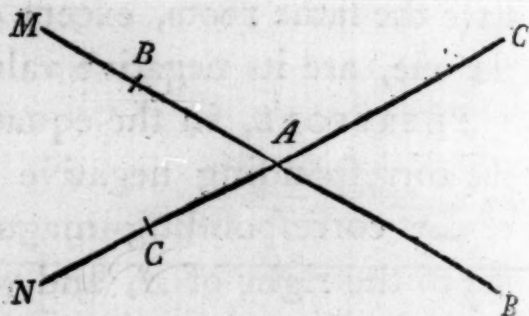
AND, *lastly*, That the corresponding negative values of x and y , are the determinations of AB , BC , when AB lies to the left, and BC lies below AB .

THE observations which have been made under the head of determinate equations, are equally applicable to those which are indeterminate. And the foregoing demonstration may be easily extended to any number of indeterminate quantities.

II. Of the Negative Quantities which are not the Roots of the Equation.

BESIDES the roots of the equation, or the quantities to be determined, problems frequently occur, which require us to consider some of the *given* quantities, as capable, consistently with the conditions of the problem, of existing in one or other of two opposite situations, which may be represented by addition and subtraction.

SUPPOSE, for instance, that the given lines $AB = a$, $AC = b$, may be taken either on the right or left of the given point A ; and let the problem be reduced to an equation, upon the supposition that they are each taken to the right. This equation, when ordered according to the powers of a and b , will be represented by the following general formula :



$$L \dots p + qa + rb + sa^2 + tab + vb^2 + \mathcal{C}c. = 0.$$

IN the lines AB , AC , and on the left of the point A , take $AM = A$, $AN = B$, of any magnitudes, not less respectively than a , b .

THEN the equation L may be reduced to the form,

$$M \dots \left\{ \begin{array}{l} P \\ + 2A + 2a \\ + RB + \dots + Rb \\ + SA^2 + 2SAa + \dots + Sa^2 \\ + TAB + Tba + TAb + \dots + Tab \\ + VB^2 + \dots + 2VBb + \dots + Vb^2 \\ + \mathcal{C}c. \end{array} \right\} = 0.$$

And

And this again is reducible to the form,

$$N \dots P + Q(A+a) + R(B+b) + S(A+a)^2 + T(A+a)(B+b) + V(B+b)^2 + \text{Ec.} = 0.$$

THIS equation, therefore, is another expression of the conditions of the problem, upon the supposition that AB , AC are taken to the right of A .

Now, by reasoning in the very same manner as before, it is evident, that when AB or AC is taken to the left, the conditions of the problem will still be expressed by an equation, which will, in all respects, be the same with L , except only, that the quantity which has changed its situation, will change its sign.

FROM the whole, the two following conclusions seem to be demonstrated.

1. WHERE the problem allows us to consider x , any of the unknown or indeterminate quantities, as capable of existing in two opposite situations, which may be represented by addition and subtraction; then the equation, which expresses the conditions required of x in one of these situations, and whose positive roots determine the magnitudes of x in that situation; the same equation, by its negative roots, will determine the magnitudes of x in the opposite situation.

2. WHERE the problem allows us to consider a , any of the given quantities, as capable of existing in two such opposite situations; then the equation which expresses the conditions of the problem, upon the supposition that a is in one of these situations, will be reduced to the equation expressing the conditions of the problem on the contrary supposition; by simply changing the sign of a , or, in other words, the sign of the terms involving the odd powers of a .

V. EXPERIMENTS *and* OBSERVATIONS *upon a* REMARK-
ABLE COLD *which accompanies the* SEPARATION of HOAR-
FROST *from a* CLEAR AIR. By PATRICK WILSON, M. A.
F. R. S. EDIN. *and Professor of Astronomy in the University of*
GLASGOW.

[Communicated by Dr BLACK; and read by Dr WALKER, Secretary,
July 5. 1784.]

S E C T. I.

MACFARLANE Observatory, Glasgow College, Feb. 14. 1784.

IN the seventieth and seventy-first volumes of the London Philosophical Transactions, the reader will find an account of some Experiments and Observations made here upon cold in the years 1780 and 1781.

THOUGH, at first, I had no other view but that of keeping a register of the very cold weather which set in on the 13th January 1780, yet I was soon led to extend the plan of my observations, upon meeting with a new phenomenon, which appeared to me to deserve some attention. This phenomenon consisted in a constant difference of temperature of the snow which, at that time, covered the fields, and that of the air at a few feet above: the snow being the coldest.

HAVING, by careful and repeated trials, fully assured myself of the fact, I was insensibly drawn to form some conjectures as to the cause. The most obvious suggestion was, that such an excess of cold depended upon an evaporation from the snow; especially when it was considered, that this substance, from its
spongy

spongy and flaky contexture, must expose a vast quantity of surface to the action of the external air.

THIS view of the matter appeared to me still more probable, from having formerly been witness to a very quick evaporation of icy films from the surface of polished metal at very low temperatures; and from other experiments, demonstrating the actual evaporation of ice, of which I had read an account in the French Memoirs.

HAVING always been a great admirer of Dr BLACK's Philosophy, in regard to heat and cold, and considering the present phenomenon as an immediate consequence of his law of evaporation, I resolved to attend to it further, in all its circumstances, from a desire of extending a little the boundaries of that induction which, in his hands, has been so fertile in general principles of so much importance.

IN the two papers above quoted may be seen by what steps, as opportunities offered, I followed out this design, and how very early I was perplexed by facts which seemed strongly to evince, that no evaporation whatever was going on when the excess of cold, at the surface of the snow, was perceivable. On the contrary, the further the experiments were pushed, the stronger were the presumptions, that the air, so far from absorbing from the snow, or wasting it by evaporation, was all the while depositing hoar-frost profusely upon its surface, as well as upon all other bodies with which it had a free communication.

THE following extract from the paper of the year 1780, will set this in a strong light, and will show, how far my first impressions were obliged to yield to the authority of facts.

" ON Sunday night, January 23. 1780, several things were
" laid out at the Observatory, such as sheets of brown paper,
" pieces of boards, plates of metal, glasses of several kinds,
" &c. which all began to attract hoar-frost, seemingly as soon
" as they had time to cool down to the temperature of the air.

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" The

“ The sheets of paper, being thin and easily cooled, acquired
“ it soonest, and, when beheld by candle-light, were beauti-
“ fully spangled over by innumerable reflexions from the mi-
“ nute crystals of hoar-frost which had parted from the air.

“ EVIDENT symptoms of the same disposition of the air to
“ deposit hoar-frost occurred on all the former nights of ob-
“ serving, and the tubes of the thermometers were so much
“ crusted with it, that it required some attention to keep that
“ part which corresponded to the scale quite free.” At the end
of said paper is the following scholium :

“ THESE experiments, indeed, rather favour the opinion of
“ the excess of cold at present treated of, depending upon a
“ principle the very reverse of evaporation. But till opportu-
“ nities offer, in this, or in a colder climate, of making more
“ experiments, it will be too early to say any thing very de-
“ cided concerning the nature and extent of a cooling process
“ which has so recently come under observation. All that can at
“ present be affirmed is, that, in certain circumstances, such a
“ process takes place ; and that it depends probably upon some
“ principles different from evaporation.’ At the same time, some
“ of the experiments show, that a free communication betwixt
“ the snow and external air, perhaps whilst in motion, is ne-
“ cessary ; but in what manner this promotes the refrigeration
“ does not as yet appear.”

THE experiments gone through this first season, rendering it
so difficult to account for the phenomenon by an evaporation
from the snow, the next step was, to comprehend, if possible,
by what other means such a cooling process could be maintain-
ed, consistently with those general principles which were al-
ready known to have a real existence ; and to this point, I con-
fess, I frequently turned my thoughts, from a suspicion of there
being something singular and undiscovered at bottom.

ACCORDINGLY, before the return of the succeeding winter,
several views occurred, concerning which it was proposed to
make

make an appeal to experiment as soon as the frost should afford an opportunity.

FIRST of all, it did not seem impossible, that the air, in such low temperatures, might impart some saline ingredient to the snow, along with the hoar-frost it so freely deposited; and, by that means, produce a constant liquefaction at the surface, which, though very inconsiderable, might be sufficient to prevent the snow from acquiring the warmth of the higher air. I was led to this random suspicion, by having observed that snow, after lying for some time on the ground, acquired a certain degree of firmness at the surface, as if the parts there had caked together by the gradual intervention of some fluid medium; and this, too, in cases where such an effect seemed not to depend upon the influence of the sun in the day-time.

It was imagined also, that, in severe frost, the snow spread abroad upon the face of a country might possess a power of depurating the atmosphere from any phlogistic taint; and thus, according to some late discoveries of my very ingenious friend Dr CRAWFORD, there would be a constant production of cold, by the air in contact with the snow, absorbing sensible heat, as it was gradually so purified.

THAT property of ice, mentioned by MAIRAN, of expanding in volume whilst exposed to the action of a sharp and increasing frost, joined to the presumption from analogy, that bodies, when so expanding, must become colder by an increased capacity for heat, seemed also, in some measure, applicable to the present difficulty.

ONE other conjecture was, that the hoar-frost, in the act of separating from the air, and forming upon the snow, might assume some particular arrangement, favourable to a sudden increase of its capacity for retaining heat, and thereby give rise to a continual absorption of it; and, of course, to a cooling process.

THESE,

THESE, and such like, were the surmises which offered themselves previous to my entering upon the subject for the second time, and which I was desirous to bring to the test of experiment, not without some hopes of being able to account for the phenomenon in question, by principles already known and familiar to us. This attempt, however, ended very unsuccessfully, as may be seen by the account given in my paper for the year 1781. Indeed, neither the weather, nor other hindrances, then admitted of pursuing the experiments far; though still enough was accomplished to show something anomalous and obscure in regard to the cause sought after.

IN this state, the subject lay by till the commencement of the late rigorous season, when, having occasion to be frequently at the Observatory at late hours, on account of the approach of the Georgium Sidus to its opposition, I was again led to resume the experiments upon cold.

IN order to proceed with more certainty and expedition, I had now ready a set of ticklish thermometers, with naked balls and slender ivory scales, and all very nearly agreeing, as to their dimensions and distance betwixt the fixed points. These thermometers, upon which I set a high value, were the last my father ever constructed; and for which he selected very exact capillary tubes, having their bores, according to his improved method, so much of a flattened oval form, as to present a very obvious broad pillar of quicksilver upon the scale, notwithstanding the smallness of the balls; a property highly convenient, especially when nice experiments are to be carried on by candle-light, and in the open frosty air.

MY father's state of health not permitting him to encounter the inclemency of the weather in such night-observations, my first object was, a repetition of several of the experiments formerly made, before proceeding to others, which, by this time, had been planned with a view of carrying forward the enquiry.

DECEMBER

DECEMBER 28. 1783.

ACCORDINGLY, this night, betwixt ten and eleven o'clock, one of the thermometers was exposed to the free air in the Observatory-park, four feet from the ground, and at a considerable distance to windward of the house. To an arm which projected from a slender frame of wood, the thermometer was so applied, as to present itself sloping, not far from a horizontal position, for the greater convenience of quickly reading off the degrees. Near by the frame, another thermometer was laid down upon the surface of the snow, which covered the ground to a considerable depth. At this time, the heavens were very clear all around, and the motion of the air from the east, so soft as only to bend a little the flame of the candle, when steadily held out.

At eleven o'clock, the thermometer in air pointed to + 5, and the one upon the snow to - 7, the difference being twelve degrees. Half an hour after, they pointed to + 4 and - 7; and every thing wore the appearance of a fine settled frosty night.

I now returned to the Observatory to attend to some astronomical business. After lighting up the transit-room, I set the meridian telescope to the altitude of a star, which preceded the planet in right ascension, and which was very soon to pass the mid wire at a certain second by the clock. When the time drew near, I looked for it in the field of view without finding it. Having glanced at the index to be certain that the instrument was rightly directed, I looked for the star again, but could perceive nothing. Stepping now forward, and turning my back towards the candles, the better to behold the heavens through the transverse slit in the roof, I immediately discovered, that the star-light there was wholly gone. This was quite unexpected, as about five or six minutes before, the heavens, when

when seen through the same opening, promised a very good observation.

UPON going abroad, I found the face of things entirely changed, the heavens being now overcast, not however by clouds, but by a thick uniform haze or fogginess above, which obscured even the stars of the first magnitude. Being now out of doors, I thought of visiting the thermometers; and, upon approaching them with some caution, I found, not without surprise, that the excess of cold, at the surface of the snow, had almost quite vanished. The thermometer in air pointed to $+6$, two degrees higher than before, and the one upon the snow to $+4$: This was at fifty minutes past eleven. Till half past twelve the fogginess above continued rather to increase, when both thermometers pointed exactly to the same degree $+7$; which, at so low a temperature, and from the suddenness of the change, I could not help regarding as very remarkable, especially as nothing similar to this had occurred in my former observations.

By half an hour after one in the morning, the stars began again to shine out; when now I was amused to find the excess of cold at the surface of the snow returning. The air, by this time, was $+8$, and the snow $+4$. As the morning advanced, the atmosphere turned more and more serene, and the thermometers came to differ no less than eight degrees. The observations made at this time are set down in the following register:

DECEMBER

DECEMBER 28. 1783, at night.			AIR.	SNOW upon the ground.
II	0'clock,	Quite clear,	+ 5	- 7
II	3'0	Ditto,	+ 4	- 7
II	5'0	Overcast,	+ 6	+ 4
12	3'0	More overcast,	+ 7	+ 7
Morning.				
I	3'0	Turning a good deal clearer,	+ 8	+ 4
I	4'5	Still more so,	+ 8	+ 2
2	2'0	Clear every where, except an ill defined cloud in N. E.	+ 9	+ 4
3	'	Ditto, except a small ill defined cloud near zenith,	+ 11	+ 3
3	4'5	Very clear, except some better defined clouds near horizon, from N. to N. E.	+ 12	+ 4

DECEMBER 29. 1783.

FROM sun-setting till past ten o'clock this night, the heavens were sometimes clear and sometimes overcast, which induced me to go to the Observatory in hopes of seeing the planet, and of tracing farther the effects of such a fluctuation of the atmosphere upon the thermometers. On my way, I was overtaken by a low fog or mist, and the thermometers being immediately exposed, as before pointed, as follows :

DECEMBER 29. 1783, at night.			AIR.	SNOW upon the ground.
II	2'0	- - -	+ 11	+ 3
II	3'0	Mist increasng, and very thick,	+ 12	+ 9
II	4'5	Ditto,	+ 12	+ 10
12	1'0	Ditto,	+ 12	+ 10
12	1'5	Still very thick,	+ 12	+ 12

DECEMBER 30. 1783.

THIS night the thermometers were affected still more remarkably by the vicissitudes of the atmosphere, the snow not only acquiring the same temperature as the air, when the heavens were overcast, but thereupon becoming considerably warmer. This singular reverse will be found in the following register :

DECEMBER 30. 1783, at night.			AIR.	SNOW upon the ground.
7	o'clock,	Clear all over,	— 1	— 9
9		Ditto, wind gentle E.	— 4	— 12
10		Ditto,	— 4	— 12
11	2'0	Wind a little before this shifted from E. and E. by N. to S. and now some clouds in S. W.	— 1	— 8
11	3'5	Cloudy all over, wind S. S. W. blowing out the candles,	0	+ 4
12		Ditto,	0	+ 4
12	3'0	No intervals of sky, but a general uniform cloudiness which hid all the stars,	+ 1	+ 4
Morning.				
1	3'0	Ditto,	+ 3	+ 9
2		Particles of snow beginning to fall,	+ 6	+ 10
2	3'0	Ditto,	+ 6	+ 10
3	3'0	More snow falling than before,	+ 10	+ 14

THE snow scale, exposed from nine o'clock till eleven o'clock and twenty minutes, gained two-tenths of an ounce of weight. THE same, when exposed from the time last mentioned till half past one in the morning, lost .07 of an ounce.

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WITH a view to some more exact statical experiments than those made in the year 1781, I had now prepared a flat circular scale, made of white iron, two feet in diameter, and turned up at the circumference about half an inch. In place of cords for hanging it to the balance, it was found more commodious to substitute pretty strong wires, by which the scale could be lifted up and set down, and carried backwards and forwards, without ever interfering with the snow upon its surface, as sometimes was the case when cords were used on former occasions. This scale was covered with snow quite to the brim, and, when cooled in the open air, it was applied to a good balance, and exactly counterpoised, by adding at last to the opposite scale very small drops of lead-shot. That no part of the external surface of the scale might communicate with the air, it was placed upon a round board, which had in it a circular space, just deep enough to receive the scale up to the brim. In this state, where nothing, therefore, but the snow which covered it communicated with the air, it was exposed abroad four feet from the ground upon a small table, at nine o'clock.

NOT only by repeated trials of the weight of this scale, but also by close inspection by candle-light, I wanted to determine at what times the air was depositing hoar-frost, or taking the same up in the way of evaporation; and particularly to mark the connection betwixt these contrary states of the air in the lower regions and a serene or clouded atmosphere, upon which last the variable temperature at the surface of the snow seemed so immediately to depend.

FOR this purpose, besides the snow-scale, there were exposed a variety of bodies, such as glass, metal plates, sheets of dark coloured paper, a plank of wood, china, &c.

UPON frequently examining all these bodies by candle-light, from nine o'clock till twenty minutes past eleven, it was quite manifest, that they were drawing hoar-frost from the air, and in the same order as is mentioned in the quotation from the ex-

periments made in the year 1780, except in one instance, which shall be particularly taken notice of in the sequel. Agreeably to this, it was found also, that the snow-scale was all the while gaining weight, as marked in the foregoing register. From the register also, it is manifest, that this deposition of hoar-frost took place whilst the air was serene, and whilst there was an excess of cold at the surface of the snow.

FROM twenty minutes after eleven till half an hour past one in the morning, there were very plain indications of all these substances surrendering to the air, though indeed slowly, the hoar-frost which had been before imparted to them; whilst the snow-scale, as is marked in the register, was losing weight. From the register it also appears, that all this happened when the heavens were overcast, and when the snow upon the ground was of a higher temperature than the air.

DURING most part of the winter, the atmosphere was extremely liable to change from a serene to a foggy or clouded state, and *vice versa*. These alternations affecting the cooling process at the surface of the snow, in so particular a manner, I was frequently led to repeat the observations and statical experiments which have just now been described, without meeting with any difference in the circumstances worthy of being mentioned. The phenomena of the nights of December 28. and 30. occurred frequently afterwards in the same order, but particularly in the night of January 25. when the heavens were overcast three times, and turned twice clear in the space of six hours.

R E M A R K S.

FROM the foregoing registers, observations, and experiments, as also from those of the years 1780 and 1781, it seems evident, that the snow continued colder than the air four feet above it, only so long as it was attracting hoar-frost at its surface; and that whenever this attraction ceased, and even when it was followed

lowed by a slow evaporation, the snow turned quickly as warm and sometimes warmer than the air.

How difficult soever it may be, upon known principles, to account for the connection between the excess of cold at the surface of the snow and its attracting hoar-frost, it is yet easy to understand how the snow may become as warm or warmer than the air above, notwithstanding an evaporation takes place. For though, from Dr BLACK's general laws, a certain waste or absorption of sensible heat must thereby infallibly ensue, it is evident, that a much drier state of the air, and a much more rapid evaporation, may be necessary to prevent the uppermost stratum of snow from being heated by the much warmer snow immediately beneath: For, on December 30. when the frost was very intense, the snow was so warm as $+ 24$, at a little more than three inches below the surface. And this I take to be the reason why the excess of cold, at the surface of the snow, so readily disappears when the attraction of hoar-frost is suspended, and, along with it, that active cooling process which seems, some how or other, to be its concomitant.

WHEN the atmosphere, after having been, for some time, very serene, becomes suddenly clouded, it is certain also, that this change must be attended with the extrication of much sensible heat in the higher regions, where those vapours are congregated. A store of heat, so produced, must soon affect the mass of air which lies below. It is well known also, that the lower air, thus rising in its temperature, will be less disposed than before to give out any matter in the form of hoar-frost, or may be even enabled to absorb this from the surface of the snow, and of other bodies, in the way of evaporation. Hence may be understood, how, upon the sudden formation of clouds or fog, the thermometer, exposed to the air, always rose some degrees; and how, in consequence of this increase of temperature, the snow-scale, and other bodies, no longer attracted any hoar-frost; and, finally, how the excess of cold at the surface

face of the snow, considered as a phenomenon, either wholly or in a great measure depending upon a constant attraction of hoar-frost, always vanished when the heavens were overcast, or when any fog or haziness interrupted the clearness of the lower air.

THERE is, however, one circumstance to be found in the register of December 28. which seems repugnant to the explanations that have now been attempted. From midnight till near four o'clock that morning, the air continued to rise in its temperature, and at such a rate as seems incompatible with the constant giving out of hoar-frost, and with the corresponding excess of cold, which took place at the surface of the snow, unless we suppose, that the warmer air, which successively arrived at the place of observation, was, at the same time, more and more charged with vapours, for which, it must be confessed, we have very little or no evidence.

A DIFFICULTY of this kind coming in the way of our general reasonings upon such phenomena, rather leads to a suspicion of there being some other principles concerned, which as yet may have altogether escaped observation. I have been the more inclined to harbour such a suspicion, since reading lately in the Berlin Memoirs for 1780, a Dissertation by M. ACHARD upon the disposition of the air to shed night-dew, in which there are some curious remarks. It is much to our purpose here to take notice, that this author mentions particularly the sudden overcasting of a serene sky, as having frequently come under his observation; and that it was always accompanied with most sensible and desultory changes in the electricity of the lower air. The scope of M. ACHARD's Memoir, is, to show how much electricity is concerned in the phenomena of the atmosphere, and how necessary it is, in all our meteorological researches, to have respect to the operations and effects of such a principle. According to this author, the different dispositions of the air, as to giving out and taking in moisture,

moisture, depend much upon its state of electricity. It might, therefore, be much worth while to examine experimentally, how far the same principles may co-operate with the more general causes above assigned, in regulating the affinity betwixt the air and the hoar-frost dissolved in it; and how far the like phenomenon of cold may take place upon the separation of night-dew from a clear air in milder seasons.

If the watery principle, when united to the air in a warm as well as in a very cold temperature, existed in the state of vapour, or under any other form and constitution similar in both cases, one should expect some difference in the phenomena, when, in the first case, it is yielded to bodies in the form of moisture, and, in the last, in the form of hoar-frost; because we are certain, from Dr BLACK's discoveries, that the same quantity of the same kind of matter under the one and the other of these two forms, contains a very different quantity of absolute heat.

UPON the present supposition, therefore, if it should be found, that the cold produced when bodies attract moisture from the air, is no greater than what is produced when they attract hoar-frost, this would amount to a proof, that the cooling process is much more active in the last case than in the first; or, in other words, that the waste of sensible heat, effected by the unknown cause, is much greater, in the act of separation, when the air deposits hoar-frost, than when it deposits moisture.

S E C T. H.

HAVING now been assured, by so many arguments drawn from experiment, that the excess of cold at the snow had a constant dependence upon its attracting hoar-frost from the air, I was next desirous of learning, whether an equal degree of cold would obtain when the hoar-frost was attracted by substances of a similar loose contexture.

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THE issue of experiments, made with this view, seemed to offer an alternative, according to which any farther researches might be conducted to greater advantage: For as yet, I was uncertain, whether so anomalous a phænomenon originated from some property of snow in relation to the air at the time of giving out its hoar-frost, or whether it depended upon the mere separation of hoar-frost from the air, by that affinity which bodies in general have to hoar-frost. I accordingly began with the following trial:

JANUARY 24. 1784.

THIS night, the heavens being very serene, and the wind coming gently from the east, and every thing without doors greedily attracting hoar-frost, the snow-scale, formerly mentioned, was exposed upon a long frame, four feet high. Towards the other end of the frame, I placed a circular board, of the same diameter, covered with fine flinty sand, free of dust, much like that made use of for sand-glasses. A thermometer was laid upon the snow in the scale, and another upon the sand, with their naked balls, within a few inches of the most leeward side. A foot to windward, and at an equal distance from the scale and board, and even with their surface, another thermometer was exposed to the air. After waiting a considerable time, with some curiosity, to know the issue of this experiment, I returned to view the apparatus at half an hour after ten o'clock, when, at once, I found reason entirely to relinquish all my former conjectures, by which, I thought, I might possibly account for the phænomenon, by some properties peculiar to snow: For now I saw distinctly, that the excess of cold was most remarkable at the surface of the sand. At this time, the thermometer exposed to the air, which afterwards swept the apparatus, pointed to $+14$, whilst the one upon the snow pointed to $+10$, and that upon the sand to $+8$. I continued to observe till half an hour after one in the morning; and

and that upon the sand to + 8. I continued to observe till half an hour after one in the morning ; and the following register shows how the thermometers pointed according to their several situations :

JAN. 24. 1784, at night.				AIR.	Snow-scale.	Sand-board.	Snow upon the ground.
10	30'	o'clock,		+ 14	+ 10	+ 8	
11	15'	-		13	10	8	
11	20'	-	-	11	8½	6½	+ 5
11	40'	-	-	12	8½	7	
11	55'	-	-	10	7½	6	6
12	45'	-	-	12	9	7	
1	30'	-	-	12	10	8	6

By examining the thermometers so frequently I had occasion to remark, that the balls and stems of the two which lay upon the snow and sand were crufted with hoar-frost much sooner than the other which was to windward in the air. The one upon the sand contracted hoar-frost the soonest, and, what at the time I thought strange, more early than the fourth thermometer which I had laid down upon the snow at the ground. In regard to the thermometer in air, I should rather think it attracted no hoar-frost whatever, properly speaking, and that what was discernible upon it proceeded from accidental minute floating particles which clung to the glass, and afterwards entangled more of the same kind : For the ball of this thermometer was not, like the one belonging to the sand, crufted over with an uniform dead silver whiteness, but was beset with a number of small tufts or prickles of the hoar-frost, whilst the intervals of glass between them were entirely clear.

With a view to a repetition of the statical experiment, I had carefully ascertained the weight of the snow-scale and sand-

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board

board immediately before I first set them out; and after they had remained abroad from forty-five minutes past nine till near two o'clock in the morning, they were again weighed, when the sand had gained four-tenths of an ounce, and the snow very nearly three-tenths.

A LITTLE after midnight, a thin circular board, which had been previously cooled, was put over the sand, and supported at the distance of about an inch and a half above the surface. After seventeen minutes, it was removed, when the thermometer on the sand pointed lower than the one in air by only two degrees; and probably, for the greatest part of this interval, the cooling process had abated.

IN a letter with which I had been favoured this day from Dr BLACK, by whose correspondence upon this subject I think myself highly honoured and obliged, there was suggested an experiment with gauze to be laid over the thermometer, which was accordingly tried. For this purpose, I fastened with pack-thread a piece of open gauze to a hoop of eight inches diameter and an inch deep; and, when the thermometers were sheltered in this manner, the quicksilver commonly rose nearly two degrees.

JANUARY 26. 1784.

HAVING now found, that the sand was more efficacious than the snow in promoting this singular kind of refrigeration, I this night repeated the last experiment with fine powder of wood charcoal, the loose shavings of brass gathered from a turner's lath, a friable amalgam of quicksilver and tin, the sand and the snow, to see if there would be any remarkable difference in the cold produced by substances differing so much in their nature and density. The apparatus consisted of circular boards, two feet in diameter, which I ranged in order upon a long slender frame, set at right angles to the direction of any air that was stirring. I then covered them with the various materials

materials I had collected, and laid a thermometer upon each, near the leeward side, as usual.

THE result was, that all, except the snow, kept nearly of the same temperature, full six degrees below that of the air, at the same height, and immediately to windward, which then was + 12. The sand seemed rather the coldest, and the snow obviously nearest to the heat of the air.

IN the mean time, the separation of hoar-frost from the air was very manifest. It was most discernible to the sight upon the sand and charcoal dust, though the manner of attaching itself to these substances was very different. On the sand, it showed itself by making the surface all over sparkle with an infinity of minute bright points, whilst, on the charcoal dust, it settled without such contiguity, and formed into many broken filaments, of a dull hue, which here and there lay clustered as if aiming at some stellated arrangement.

THE present experiment was made about midnight, when the heavens were very clear, and the wind at east and one point south, and so brisk as to trail horizontally the flame of the candle till it sometimes went out. Now and then this gentle current came suddenly straight downwards for a few seconds, as was apparent from the manner in which it affected the flame of the candle.

So long as I was employed abroad at this time, there was no fluctuation in the state of the atmosphere, nor any alternation in the cooling process. Last night, however, the case was very different, as has been already mentioned. The experiments then made were chiefly with the snow-scale and sand-board. When the heavens were overcast, both soon acquired the temperature of the air, which then was very still. It was found, too, by statical experiments, that the sand acquired an addition to its weight, when it happened to be for some length of time colder than the air; but when the cooling process was interrupted, and the sand continued for some time of the same tem-

perature as the air, the scale gradually became lighter, though in a small degree.

R E M A R K S.

IN estimating the degree of refrigeration at the surfaces of the various substances upon the board, the thermometers were always laid down at the leeward side, as has been so frequently mentioned. This was soon found to be a necessary precaution; for, when exposed in any other situation, the cold shown was less considerable. I was, indeed, led very early to suspect such a result, upon considering, that this very cold air, though prone to give out hoar-frost, might not all at once be disposed to part with what was redundant, though solicited by bodies capable of receiving it. The consequence of this seemed to be, that any given portion of this very cold air, in flitting slowly over the sand, &c. would part with more and more hoar-frost, and, on that account, become colder and colder, so as to be coldest of all near the leeward side; or, in other words, would be thrown into a *fit of continual refrigeration* in its passage over the boards, which circumstance was found to be agreeable to experience.

THIS fact, therefore, seems very consonant to all the rest, as indicating, in another way, the relation between the separation of hoar-frost from the air, and the apparent waste of sensible heat. Having brought this topic into view, it may perhaps be worth while to pursue it, for a moment, a little farther.

IT has been already observed, that the thermometer upon the sand-scale was much sooner crusted over with hoar-frost than the one in air to windward. This, indeed, is what might have been expected, on account of the last of these two situations being the warmest. But as the thermometer upon the snow at the ground was always colder than that upon the sand, it does not so readily appear, how this last should have attracted hoar-frost sooner than the first. This fact seems to show, that any
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portion of air, by being thrown into a fit of continual refrigeration, by the action of the surface over which it travels, is, upon its arrival at the leeward side, and during the fit, disposed to part with a greater quantity of hoar-frost in a given time, than what otherwise it would do, even though equally cold. According to this idea, were the surface so much extended as to bring the fit of refrigeration to a maximum, and so put an end to it, before the arrival of the air at the leeward side, a body at this leeward side would acquire hoar-frost more slowly than another lying somewhat more to windward, to which the air can reach whilst in the fit of cooling. Thus, therefore, in regard to the greater part of the air, which sweeps the endless continuous surface of the snow upon the ground, we may conceive the fit of refrigeration as consummated; on which account, it will be less disposed than that which crosses the sand upon the scale to give out its hoar-frost: And, in this way, the fact under consideration may be accounted for.

FROM a desire of making some more formal experiments upon the air whilst in this progress of cooling, by the action of surfaces exposed to it, I provided a wooden canal, fifteen feet long, a foot wide, and fifteen inches deep. This canal, open at both ends, and with its bottom covered with the fine sand, I intended to have exposed on some favourable night for the frosty air to glide along it; and by thermometers placed at certain intervals, as well as plates of metal, &c. which I could bring to the test of a balance, to have determined the greatest degree of cold, and the rate of cooling, and of giving out hoar-frost, from the windward to the leeward end: But before I could conveniently enter upon this experiment, I was stopped by the thaw. Perhaps a platform of deals laid close to one another, and covered with sand, would be a much better apparatus; as the more a surface, designed for such a purpose, is extended in breadth, the warmer air would the less readily flow in sidewise, so as to mar the effect produced by the flow current

rent advancing to leeward. It would not be wonderful, though somewhere upon an elevated and detached platform of this kind, we should find an *artificial cold* greater than what prevails at the same time on the snow at the ground; as the warmer snow, which lies immediately beneath, at least for the most part, must more or less counteract the cooling process kept up there.

BUT to return from this digression, I now come to relate the most striking experiment I had an opportunity of making this winter, during the time I was occupied in such cold vigils.

IN some of the sereneest and stillest nights, having frequently amused myself by attending to the capricious arrangement of the hoar-frost as it settled upon different bodies, I was led to remark, that quicksilver was a long while of attracting any, and even at last sparingly, and chiefly at those places of its surface which were sullied by a dusty film. This naturally suggested a comparison of quicksilver and the sand, as to their powers of contributing to the cooling process at their surface.

FOR the apparatus, I borrowed from a cabinet-maker two mahogany tea-trays, of an oval form, twenty-two inches by seventeen, and near an inch deep, inside measure.

JANUARY 29. 1784.

ABOUT nine o'clock at night, I placed them out in the park upon a slight plane-tree table, about a foot asunder, and with their longer axes pointing to windward. After levelling one of the trays, its bottom was completely flooded over with quicksilver, to the amount of twenty-four pounds weight, which Messrs HILL and MONTEATH, surgeons and druggists here, most obligingly lent me for that purpose. The bottom of the other tray was covered to the depth of a quarter of an inch with the fine flinty sand. Upon each of the surfaces of the sand and of the quicksilver, I laid down a thermometer, with the ball near to the leeward end as usual, and exposed a third

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to the air, about a foot to windward, and even with the trays. I then left them for an hour to cool; after which I continued to observe them now and then for two hours more. During all this time, I found, that the thermometer placed upon the quicksilver continually pointed higher than the other upon the sand, as set down in the following register :

JAN. 29. 1784. at night.	AIR.	Tray with quicksilver.	Tray with sand.	Excess of cold on the quicksilver.	Ditto on the sand.
10 o'clock,	+4	+3	— 1	1	5
10 30' -	+3	+2	— 1	1	4
11 -	+3	+2	— 1½	1	4½
11 30' -	+3	+1½	— 1½	1½	4½
12 -	+4	+2	0	2	4

To make sure of every thing in this experiment, especially as the extremes of temperature were but inconsiderable, I sometimes changed the thermometers, and shifted the sand-tray from the right to the left side of the other, without at all altering the report. Whilst this experiment was going forward, I discerned plainly all the common symptoms of the hoar-frost joining the sand, and settling upon the inside and outside wood of both trays. Though at length, some made its appearance upon the face of the quicksilver, yet I am apt to think, that the cold generated all around by the hoar-frost which attached itself to the wood, was the chief cause of the quicksilver keeping below the temperature of the air to windward.

It afterwards occurred to me, that, in this experiment, it would have been proper to have filled the tray with quicksilver to the very brim, and to have defended the outside wood from the air by some rare substance. Had things been so managed, and the other tray completely filled also with sand, and defended in the same manner, I am persuaded the result would have been more remarkable; and that the quicksilver, thus exposed with
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an unfullied face, would have kept as warm as the air to windward, how much soever the sand might have been colder.

BUT taking the result of this experiment as we found it, we may safely regard it as an instance of what may be called the same volume of air in one part, laying down its vapour in the form of hoar-frost, and in another, passing away without such a decomposition taking place. In the former case, we accordingly found the corresponding cold produced, but very small indications of any such thing in the latter.

As quicksilver thus resists the hoar-frost, so may some other substances; and, on the contrary, there may be some much more fitted than others to promote this sort of decomposition of the air in low temperatures. But this suggests a variety of experiments which I have had no opportunity of pursuing. Certain late appearances have made me think of trying a broad surface, made up of a combination of wool-cards, having observed something like a preference of sharp points in the settling of hoar-frost.

THOUGH it would require many more experiments than our opportunities have allowed of, to understand fully several points belonging to this Enquiry; such as, the fits of refrigeration of the air, and the corresponding aptitude to part with its hoar-frost, yet the foregoing experiments, registers, and observations, when attentively considered and compared with one another, and with those narrated in the two papers published in the London Philosophical Transactions, seem to conspire in support of the following

GENERAL CONCLUSIONS:

That when bodies attract hoar-frost from a clear air, there is a cold produced at their surfaces; and that this cold does not originate from any peculiar qualities of bodies upon which the hoar-frost settles, any farther than as some bodies are capable of attracting from the air more or less of it in a given time:

That

That the disposition of the air of thus parting with hoar-frost, and the cold which accompanies that separation, has a constant dependence upon the general serenity of the atmosphere, and is always interrupted upon the sky being overcast with clouds or fogginess, especially near to the place of observation.

THE analysis which has now been detailed, though imperfect in many respects, seems, however, to demand our assent to these general propositions, how anomalous soever they may appear.

THE nature or essence of the thing we call HEAT is so far removed beyond the immediate reach of our senses, that we need not wonder though new facts relating to it come into view, and even though they cannot immediately be traced up to any general laws hitherto established. If, upon mature reflection, the present phenomena cannot be accounted for in this way, they ought, on that very account, to challenge our attention the more, as opening to us the necessity of enlarging our stock of principles, and inviting us forward to so desirable a work.

IN the *first* proposition above laid down, it is asserted, that the cold produced is in proportion to the quantity of hoar-frost separated from the air in a given time. This, however, must be understood with some limitation, and may not perhaps hold true, if we compare together the degrees of cold and quantities of hoar-frost separated in different states of the air.

THE import of the proposition only is, "That, at any given time, the more hoar-frost the air imparts to bodies over which it passes in a clear state, the greater is the cold then produced." For it is very conceivable, that, according to the different states of the air, in different seasons, or in different nights of the same season, arising from its being more or less charged with vapour, or perhaps with electricity, or some other

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latent principles, the quantity of hoar-frost given out, compared with the corresponding cold, may be very different.

IN the paper of the year 1781, it is said, "That last year
" there was a much more copious giving out of hoar-frost at
" times when the difference of temperature was not more re-
" markable;" and, from this fact, I was then disposed to con-
clude, that the cooling process had no immediate dependence
upon the separation of hoar-frost. But, from the facts which
have been ascertained this winter, it seems necessary to correct
this opinion in the extent above explained. It ought also to be
considered, that the comparison above quoted between the
years 1780 and 1781, had respect to the temperature of the
snow upon the ground only; and it is evident, that this may,
cæteris paribus, differ more or less from that of the air, accord-
ing as the snow has fallen more or less recently, or is more or
less deep, upon warm or upon frozen ground.

It may also be proper here to take notice of what may be
called a spurious kind of hoar-frost, which is attended with no
cold whatever at settling upon bodies. I mean that which trees
and buildings are so apt to be decorated with during a mist in
frosty weather; in which case it is obvious, that the hoar-frost
was previously formed in the air, and floated in it, and was not
formed in the act of being deposited upon the body.

S E C T. III.

THOUGH the night-observations of this and the former win-
ters afforded so many examples of cold thus depending upon
the separation of hoar-frost from the air, I come now to men-
tion one, and the only one instance wherein, during the night,
this condition of things was totally reversed, and when the
same phenomenon, of an excess of cold at the surface of the
snow, took its rise from a most manifest evaporation.

JANUARY

JANUARY 28. 1784.

ABOUT nine o'clock this night, the excess of cold was four, five, and sometimes six degrees. The circumstances of the weather, indeed, were now very particular. With the air so warm as + 27, the sky was quite clear, whilst a strong wind blew directly from the north. At the same time, too, the heavens were illumined with a most vivid display of the Aurora Borealis, which shooed from the north, round by the east, and up beyond the zenith towards the south, where the wandering irradiations all converged, so as to form an imperfect crown.

DURING this play of the elements, there were no longer to be found the smallest traces of that hoar-frost about which I had so often been employed in calmer and in colder times. Early in the afternoon, I had laid out a parcel of things, which might show me the state of the air when night should come. But neither upon them, nor upon the wooden spars of the wicket which opens from the fosse round the Observatory to the park, nor upon its side-stones, nor the hedge, nor the thorn-tree near by, was there to be seen the smallest particle. Every thing around was entirely stripped of hoar-frost by this dry and devouring gale.

THE sand-board and snow-scale, set out as formerly, gave now a very different report. The thermometer on the sand never cooled a fraction of a degree below the temperature of the air, whilst the sweeping wind cooled down the snow several degrees. Evaporation in all this was so evidently concerned, that it would have been absurd to have tried if the sand had lost weight in that way. But, at any rate, such an attempt would have been difficult, as the sand was so liable to be dispersed by the wind, that I was obliged to lay it very thick upon the scale, and to shelter it a little under the lee of the hedge. Being, however, desirous to know, at what rate the snow wasted by evaporation in this situation, I got the white iron scale, with

snow compressed upon it, muffled from the wind by a piece of open gauze. In this state, when exposed for two hours, it lost six-tenths of an ounce. Now and then I looked to see if any of the snow was drifting away through the gauze, but could perceive none traversing the beams of the candle, when the lantern was held in the most favourable position for detecting such a thing; and I rather think that the whole waste was owing to evaporation.

SINCE the above date, I have sometimes, in the course of observations, made commonly from nine o'clock in the morning till mid-day, found the like excess of cold upon the ground snow, proceeding from actual evaporation; and this too when the weather was much more calm. But, on all these occasions, it was evident, that the air was rising quickly in its temperature, as the sun approached the meridian. On this account, may it not be supposed, That the air was acquiring, not only a power of keeping dissolved what, during the night, it would have deposited as hoar-frost, but of causing such an evaporation from the snow, as to produce an observable cold by that process? Whatever there may be in this supposition, the fact is certain as above stated.

WHEN the air is not very frosty, I am inclined to think, from the above observations, that a cold, in consequence of evaporation in the day-time, takes place not unfrequently, and that this may be one cause of that profuse giving out of hoar-frost which night brings along with it, when the work of refrigeration is still continued by that other process which has been the subject of this Essay.

THE following I have always found to be a characteristic distinction between the two processes, besides the others already mentioned. A thermometer freely exposed, with its ball environed with a small mass of snow, falls sensibly below the temperature of the air which meets it, when evaporation goes on. But in the most active state of the other process, I never observed

observed such a thermometer in air point sensibly below another beside it, whose ball was perfectly clear. In short, the whole features of the one process, compared to those of the other, are so dissimilar, as to shew evidently they depend upon principles of a very different nature.

IN the prosecution of so dark a subject, we have proceeded hitherto entirely in the way of analysis, and have been careful to prevent any supposition or conjecture from mixing with, or affecting our conclusions. But having now arrived at what appears to be a general and leading fact, and of so anomalous a kind, the situation obliges us, more or less, to take up with surmises, as guides to farther experiments; in the view of finally reconciling the present phenomena with what we already know concerning the nature and properties of heat.

WHEN such a cold is produced, as that which has been considered at so much length, the question is, What becomes of the sensible heat which thus constantly disappears?

FROM the experiments mentioned in the paper of 1781, we are disposed to think, that this heat does not enter into the composition of the hoar-frost which is given out by the air.

IF, however, it should be found, that the air itself, at the moment the decomposition takes place, has its capacity for retaining heat much increased, such a circumstance would immediately solve the difficulty. For, by this means, the air, when parting with any given portion of hoar-frost, might absorb, not only the whole heat, which, according to Dr BLACK's law, served to keep the hoar-frost dissolved, but also, it might absorb a portion of the sensible heat belonging to the body or surface upon which the hoar-frost settles; and thus occasion a diminution of sensible temperature, or the cold in question.

BUT regarding the air, in these extreme colds, and whilst the hoar-frost is dissolved in it, as a chemical mixt, it may be demanded, What reason is there for supposing that the capacity of the air for heat should increase at the moment it gives out its
hoar-

hoar-frost to bodies attracting it? To this it may be answered, since we are confessedly dealing in surmises and conjectures, that, possibly, in the mixed subject we are now contemplating, there may be a third ingredient, of an electrical or phlogistic kind, and which is necessarily separated from the air along with the hoar-frost.

ACCORDING to this view, with the help of Dr CRAWFORD's general fact mentioned above, we could account for the cooling process, by saying, that it depends upon the increased capacity of the air for heat, in consequence of its being dephlogisticated by the mediation of a third substance, namely, the hoar-frost, which, by a predominant affinity, in certain cases, is made to part from the air, and unite itself to the attracting substance.

It would require, however, many nice and well ordered experiments, before the merits of a suggestion, so arbitrary as this is, could be determined.

BUT how much soever we may be at a loss to understand in what manner cold is produced by the separation of hoar-frost from a clear air, or what becomes of the sensible heat which, in that process, constantly disappears, yet, by regarding the thing itself as a general fact, now demonstrated by a competent induction, it seems already to offer us some assistance in explaining, by the synthetical method, certain phenomena connected with our subject. Of this, what has been mentioned of the two thermometers, page 172. may serve as an example.

IN the first case, we know so much of the nature of evaporation as to be certain, that any portion of air, relatively dry, at meeting the small mass of snow surrounding the ball, must produce cold, more or less, even by the most transient contact. By a constant succession, therefore, of such evaporating air, the mercury in the thermometer will be made to sink very sensibly below that of another exposed to the same current, having no snow round its ball.

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BUT when the air is in a contrary state, and disposed to give out hoar-frost, the ball, with the snow round it, may be considered, according to the new ideas we have acquired, as not affording surface enough for the extrication of hoar-frost from any portion of air, during so momentary a contact, in passing to leeward. For, from several phenomena already insisted upon, it seems evident, that an action, continued for some length of time, is necessary for unlocking the hoar-frost from the air, and conveying it to the attracting surface. Hence the thermometer with the snow round the ball, in the circumstances supposed, should not be cooled more than the current of air in which it is placed; and thus this characteristical distinction betwixt the two processes may be accounted for.

IN like manner, may be understood, how it is in the clearest and stillest nights only, that the cold at the surface of the boards was observed to be most remarkable. For, according to what has been just now mentioned, any very rapid motion of the air across these surfaces, seems inconsistent with the extrication of hoar-frost, upon which the refrigeration depends.

FURTHER, in the paper of the year 1780, an account is given of an experiment, which consisted in blowing the ambient cold air upon the snow where the thermometer lay, and of fanning the same briskly with a piece of stiff paper fastened to the end of a long stick, in expectation that the thermometer would point lower by an increased evaporation. This experiment was made pretty early, and whilst I was in the persuasion, that the observed excess of cold depended entirely upon evaporation. The result, however, was, that the thermometer, instead of pointing lower by such means, always rose several degrees. Though this circumstance was thought odd and unaccountable at the time, yet the true reason of it seems now to offer itself very plainly. For, from the explanations attempted in the two foregoing paragraphs, it would appear, that, by the operations with the bellows and fan, we had all the while been disturbing
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that more leisurely and intimate communion betwixt the air and the snow, which is necessary to the extrication of hoar-frost; and that accordingly the thermometer approached considerably nearer to the temperature of the air.

“ THAT the extrication of hoar-frost requires an action continued for some length of time, upon a given portion of air,”

is a proposition of some moment, because, taken along with the other general fact, it enables us so easily to explain certain collateral phenomena which so much characterise this kind of cooling process; some examples of which have now been produced. On that account, it might be worth while to establish the proposition farther, by more direct experiments. For this purpose, a simple apparatus might be constructed for making the air, in night-observations, to pass with different rates of velocity over the cooling surfaces, in order to discover how much the extrication of hoar-frost, and the cold produced at the leeward side, depends upon an undisturbed and leisurely communication between the air and the substances exposed. As to the issue, I am already almost entirely convinced, that, were the natural flow passage of the air over the surfaces changed suddenly, by machinery, into a rapid current, the thermometers at the leeward side would very soon rise, if not to the same, at least nearly to the same temperature as the air to windward.

It might also be proper to try how far, and for what length of time, a considerable quantity of cold air, when shut up on all sides from the external atmosphere, would, by a leisurely and successive application of all its parts to a surface of sand, &c. keep up a cooling process; and even for this experiment, it would be no difficult matter to contrive a proper apparatus.

It is now full time that we relieve the reader, who may have followed us so far in a discussion which has swelled to a much greater extent than originally was intended, and where so perpetual a recurrence of the same phraseology, how necessary so-
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ever to the illustration of so new a subject, must doubtless have been felt as tedious. We shall, therefore, conclude with observing, that experiments of this kind fall most properly under the province of those philosophers who live in climates where the winter is of longer continuance, and attended with more rigour, and a more permanent serenity of the atmosphere. Here, in this latitude, the opportunities are so rare, and, when they do occur, so transient, that our progress in such an experimental enquiry must advance only by slow steps. To those, therefore, more favoured by situation, would we humbly recommend a farther prosecution of a subject, which, besides its entire novelty, seems, upon several other accounts, to have a claim to some attention.

VI. *An Account of the Method of making a WINE, called by the TARTARS KOUMISS; with Observations on its Use in Medicine.* By JOHN GRIEVE, M. D. F. R. S. EDIN. and late Physician to the Russian Army.

[Read by Dr BLACK, July 12. 1784.]

IN an age like the present, when few things in nature seem to have eluded the researches of philosophy, when the communications of learning are as well established as those of commerce, it may appear somewhat surprising, that one of the most important productions of milk should still remain, in a great measure, unknown to the most enlightened parts of Europe.

THE production I mean is the vinous liquor which is procured by fermentation from mares milk. And it was scarcely to be expected, that, after it had escaped the observation of men the most skilled in chemistry, it should be taught us by a horde of Tartars, whose rank in society is not above that of Barbarians.

EVEN in Russia itself, it was with difficulty I could learn the particulars of the preparation; and though it has been used, for some ages, by several tribes of people who belong to that empire, yet, in the year 1781, when I first began to think of employing it in medicine, it was as little known in what may be called *Russia proper*, as it is now in Great Britain. If the academicians of St Petersburg gave some accounts of it, these accounts have never excited the attention of the physicians of Russia.

THIS neglect is most probably to be ascribed, partly to the obscure relations of travellers, and partly to the pride of system, which

which men of learning are too often apt to indulge, in rejecting as incredible whatever does not coincide with their own preconceived opinions.

ON consulting the authors who have made mention of this subject, I find, that they give little satisfactory information concerning it. They all agree, that a vinous liquor, from mares milk, was used by some of the Tartar nations, under the name of *KOUMISS*; but none of them enter into a detail of the process by which that wine was prepared, much less does any one of them point out the purposes, either in œconomy or medicine, to which it may be applied.

MARCUS PAULUS VENETUS gives some account of it in his History of the Eastern Nations*, which was published as long ago as the thirteenth century. He says, it was used by the Tartars as their common beverage, but makes no mention of the method of preparing it.

STRAHLENBERG, in his description of the Russian empire†, relates some circumstances of the preparation; but his method, if followed, could not be attended with success; for he mentions, that the *Kalmucks* take off the thick substance, which, in consequence of souring, rises to the top of the milk, and employ this in their food, while they use the remaining liquor either for drink or distillation. Now, this is not only contrary to the usage of that people, when they wish to obtain a fermented liquor of any strength; but experience proves, that no perfect fermentation can be produced, unless all the parts of the milk be left united in their natural proportion.

GMELIN, in his History of a tour which he made through Siberia‡, pays more attention to the Tartar method of distilling a spirit from the wine of milk, than to the fermenting process by which that wine is procured.

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* De Region. Oriental. lib. i. cap. 57.

† Beschreibung des Russischen Reichs, p. 319.

‡ GMELIN's Reise durch Siberien, t. i. p. 273.

THE latest writer that I find mentioning *Koumifs*, is the celebrated professor of natural history in St Petersburg, Dr PALLAS*. His account is as circumstantial as could well be expected from a traveller, whose object was natural history in general; yet the principles on which the fermentation depends, as well as the mode of conducting the process, are not sufficiently explained in his work.

THESE accounts, however imperfect, might have led philosophers, long before this time, to a discovery of the true method of fermenting milk, had not the writings of NEWMAN†, an eminent German chemist, contributed to deceive them. He was himself imposed upon by one LUCAS, a Dominican monk, who ascribed its fermentation to the flour of millet and the grains of barley, which, he said, the Tartars added to it, and to the wine-cask in which the operation was performed. NEWMAN, it would seem, was unwilling to admit of the fermentability of milk, because it was contrary to the ideas he had entertained of an animal liquor; and, therefore, adopting the opposite opinion, he seems glad to have an authority, however weak, to support it.

VOLTELEN‡, too, a chemist of Holland, affords a striking example, how easily men are misled, even in matters of science, by their own prejudices. He had no doubt of the existence of a fermentable principle in milk, inasmuch as it contained a certain quantity of a saccharine substance. He knew also, that the whey contained the sugar in solution; it was on it, therefore, that he instituted his experiments; he added even more sugar to the whey than the natural proportion; but no vinous fermentation could, by any means, be produced in it. Nor did even his want of success undeceive him. He never once imagined, that the butyraceous and caseous parts of the milk were no less necessary to its fermentation than the saccharine and ferous.

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* *Physicalish. Reise durch einige provintz. des Russisch. Reichs*, t. 1. p. 316.

† NEWMAN, *Chem. experimental.* t. 1. part 2. p. 18.

‡ *Observat. de lacte humano cum afinino et ovillo comparato*, p. 54.

Even MACQUER, in his Chemical Dictionary *, has fallen into an error of the same kind. Speaking of whey, he says, "In whey is contained dissolved, a considerable quantity of extractive substance, of the nature of the saccharine juices, and it is accordingly susceptible of the spirituous fermentation. The Tartars certainly make from it a spirituous drink, or kind of wine." From this it appears he had not made the experiment.

THE following method of making *Koumiss*, is that which I adopted in my own practice with success. It is common among the *Baschkir Tartars*, who inhabit that part of the government of *Orenbourg* which lies between the rivers *Kama* and *Volga*. It was communicated to me by a Russian nobleman, in whose case I was consulted, and who was the first who made use of it by my advice. He went into that country on purpose to drink it; and, as he resided for some time there, he could not be mistaken with respect to the process.

TAKE of fresh mares milk, of one day, any quantity; add to it a sixth part of water, and pour the mixture into a wooden vessel; use then, as a ferment, an eighth part of the sourest cows milk that can be got; but, at any future preparation, a small portion of old *Koumiss* will better answer the purpose of souring; cover the vessel with a thick cloth, and set it in a place of moderate warmth; leave it at rest twenty-four hours, at the end of which time, the milk will have become four, and a thick substance will be gathered on the top; then, with a stick, made at the lower end in the manner of a churnstaff, beat it, till the thick substance above mentioned be blended intimately with the subjacent fluid: In this situation, leave it again at rest for twenty-four hours more; after which, pour it into a higher and narrower vessel, resembling a churn, where the agitation must be repeated, as before, till the liquor appear to be perfectly homogeneous; and, in this state, it is called *Koumiss*;
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* MACQUER Dictionary of Chemist. p. 432.

of which the taste ought to be a pleasant mixture of sweet and sour. Agitation must be employed every time before it be used.

To this detail of the process, he subjoined, that, in order to obtain milk in sufficient quantity, the Tartars have a custom of separating the foal from the mare during the day, and allowing it to suck during the night. And, when the milk is to be taken from the mare, which is generally about five times a-day, they always produce the foal, on the supposition, that she yields her milk more copiously when it is present.

To the above method of making *Koumifs*, which I have translated as literally as possible from the original Russian manuscript now in my possession, I will add some particulars, taken from other communications with which I was favoured by Tartars themselves. For though I think no addition necessary to render it either more simple or more intelligible, yet I think it my duty to withhold nothing which may, in any wise, throw light on so essential a part of my subject.

ACCORDING to the account of a Tartar who lived to the south-east of *Orenbourg*, the proportion of milk and souring ought to be the same as above; only, to prevent changing the vessel, the milk may be put at once into a pretty high and narrow vessel; and, in order to accelerate the fermentation, some warm milk may be added to it, and, if necessary, more souring.

FROM a Tartar whom I met with at the fair of *Macarieff* upon the Volga, and from whom I purchased one of the leathern bags* which

* THIS bag was made of a horse's hide undressed, and, by having been smoked, had acquired a great degree of hardness. Its shape was conical, like the figure in the margin, but was, at the same time, somewhat triangular, from being composed of three different pieces, set in a circular base of the same hide. The futures, which were made with tendons, were secured by a covering on the outside, with a doubling of the same skin, very closely secured. It had a dirty appearance, and a very disagreeable smell. On being asked the reason of this, he said, "The remains of the old *Koumifs* were left, in order to supply a ferment to the "new milk."



which are used by the Kalmucks for the preparation and carriage of their *Koumiss*, I learned, that the process may be much shortened by heating the milk before the souring be added to it, and as soon as the parts begin to separate, and a thick substance to rise to the top, by agitating it every hour, or oftener. In this way, he made some in my presence in the space of twelve hours. I learned also, that it was common, among some Tartars, to prepare it in one day during summer, and that with only two or three agitations; but that in winter, when, from a deficiency of mares milk, they are obliged to add a great proportion of that of cows, more agitation and more time are necessary. And though it is commonly used within a few days after the preparation, yet, when well secured in close vessels, and kept in a cold place, that it may be preserved for three months, or even more, without any injury to its qualities.

He said farther, that the acid fermentation might be produced by sour milk, as above, by a sour paste of rye-flour, by the rennet of a lamb's stomach, or, what is more common, by a portion of old *Koumiss*; and that, in some places, they saved much time, by adding the new milk to a quantity of that already fermented, on being mixed with which, it very soon undergoes the vinous change. It was according to the first process, however, that all the *Koumiss* which I have employed in medicine was prepared.

FROM all these accounts, it appears, that three things are essential to the vinous fermentation of milk. These are *heat*, *souring*, and *agitation*. Heat is necessary to every species of fermentation, and souring is perhaps not less so, though not in so sensible a degree as in the present case; but the chief art of fermenting milk consists in *agitation*. This last circumstance has wholly escaped the attention of chemists, notwithstanding it appears to be consonant to the operations of nature in other species of fermentation. In fermenting vegetable juices and infusions, nature has no need of the assistance of art; the intestine

testine motion which accompanies the fermentation is sufficient to produce the degree of agitation which seems necessary to keep the parts of the fluid in mutual contact, or to fit them for mutual action. Milk, on the contrary, is no sooner soured than a separation of its parts takes place; the cream rises to the top, while the cheese either falls to the bottom, or is suspended in the whey. When these parts are brought, however, into close contact with one another, by agitation, and this repeated at proper intervals, a vinous liquor is produced; of the medical virtues of which I shall now treat.

FROM the time I had heard of *Koumifs*, I had conceived an opinion of its importance in the cure of certain diseases. I judged, that a preparation of milk, which could not be curdled by the juices of the stomach, while, at the same time, it possessed all its nutritive qualities, with the superaddition of a fermented spirit, might be of essential service in all those disorders where the body is defective either in nourishment or strength.

THE case of the above mentioned nobleman, who communicated to me the first process, gave me an opportunity of trying, how far my conjectures were well founded. He was in that state which seemed to me strongly to indicate the use of such a medicine as *Koumifs*. I accordingly advised him to it.

AT twenty-six years of age, he laboured under a complication of chronic complaints. A confirmed *lues venerea*, injudiciously treated, with three successive salivations by mercury, added to bad management of himself under these, had given rise to his disease. His body was much emaciated; his face was of a livid yellow colour; his eyes were sunk, and round his eye-lids there was a dark shade; he felt a severe pain in his breast, and that was accompanied with a considerable cough and mucous expectoration; his appetite and digestion were greatly impaired; he had frequent tremblings and faintings; he began to feel the symptoms of hectic fever. In a word, his whole appearance was consumptive, and he was so weak that he

he required assistance to get into the carriage in which he was to be conveyed into Tartary.

AFTER drinking *Koumiss* six weeks only, he returned perfectly free from all the above symptoms, and was become so plump and fresh-coloured, that, at first sight, it was with difficulty his friends could recognise him. As he did not come immediately to *Nischne-Novogorod*, where I then was, he wrote me a letter, the substance of which, as far as it related to this subject, I shall give here.

AFTER telling me the sudden and remarkable change the *Koumiss* had produced, during the first few days; that he ceased to be disturbed in his sleep; that his nervous and dyspeptic symptoms left him; that he felt as if his vessels had been distended with a fresh cooling liquor; that he became cheerful; that it served him both for food and drink; that though he used it to the quantity of a gallon and a half, and sometimes even more, in the twenty-four hours, yet he always drank it with pleasure, and without intoxication; that his body, during its use, was regularly open; but that his urine was so much increased, that he was usually excited to make water every hour: He proceeded to express himself in the following strong terms, which serves to show how much he had profited by it.

“ I AM disposed to consider *Koumiss*, (says he) with all deference to you, as an universal medicine, which will cure every disease, if you do not chuse to except fever; for I am persuaded, that the most skilful physician, with all the drugs of the shop, could not have restored me to the health I now enjoy.”

THE next case in which it was employed, though not so desperate as the former, gave sufficient proofs of its nutritive and strengthening qualities. A lady, who had been witness to its uncommon efficacy in the nobleman's case above mentioned, was encouraged to try it in her own. It was not convenient for

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her to go herself to Tartary, and therefore she had it sent to her, well secured in casks, during the autumn.

SHE had been long subject to a train of nervous disorders. By these, she was much extenuated, and reduced to a state of extreme weakness and irritability. She used it for about a month, at the end of which time, the functions of her nervous system were restored, and, with health and vigour, she acquired a plumpness and fresh complexion.

THE following year, I resolved to try it at *Nischné-Novogorod* under my own eye. As mares milk could not be obtained in sufficient quantity in town, it was made at the seat of a nobleman, not far distant, from which it was occasionally transported. The season was far advanced, however, before a case was presented, in which its efficacy might be tried. At last, about the middle of August 1782, I was consulted by the General Governor's nephew. He had all the symptoms of incipient phthisis; pain of breast, dry cough, occasional hæmoptysis, and great emaciation; he was not, however, become hectic. His two elder brothers had died of true pulmonary consumptions. He had taken much medicine, in a different part of the country, and had observed a very strict antiphlogistic regimen; but though milk had constituted the greatest part of his diet, yet there were no signs of recovery. He drank *Koumifs* for about two months only, and that in rather an unfavourable season; but the consequence was, that all the above symptoms disappeared, and his flesh and strength returned; nor was there any reason to apprehend a relapse, at the time I left that country.

ABOUT the same time, I advised its use to another young nobleman, who had laboured under an abscess in the left side, about the region of the twelfth rib. As he had then resided in a remote part of the country, no attention had been paid to it; on the contrary, by improper applications, the sides of the ulcer were become hard. He had lost his flesh and strength; he had occasional faintings; and there were all the appearances of
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incipient hectic. By the use of *Koumiss* for about six weeks, proper surgical dressings being at the same time applied, his health was perfectly re-established.

THERE were some other cases in which I employed it with equal success; but of which, as being less important, I omit the detail.

ALL those who drank it agreed in saying, that, during its use, they had little appetite for food; that they drank it in very large quantities, not only without disgust, but with pleasure; that it rendered their veins turgid, without producing languor; that, on the contrary, they soon acquired from it an uncommon degree of sprightliness and vivacity; that even in cases of some excess, it was not followed by indigestion, headach, or any of the symptoms which usually attend the abuse of other fermented liquors. To this may be added, that the Baschkir Tartars, who, towards the end of winter, are much emaciated, no sooner return in summer to the use of *Koumiss*, than they become strong and fat*.

FROM all these circumstances, I think myself entitled to infer, that this wine of mares milk may be applied to many of the purposes of medicine. From the mild acid which it contains, may it not be considered as a cooling antiseptic? From its vinous spirit, may it not become an useful stimulant, cordial, and tonic? And, from its oily and mucilaginous parts, may it not prove a valuable article of nourishment? If chronic diseases, as is generally allowed, depend on a debility of the solids; and if they are difficult of cure, because the organs, which ought to supply the body with nourishment and strength, do not only themselves partake of the general weakness, but are too often, by the indigestible nature of the food with which

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* THE author of a historical description of all the nations which compose the Russian empire, says, speaking of *Koumiss*, " Elle est fort nourissante, et peut tenir lieu de tout autre aliment. Les Baschkirs s'en trouvent très bien, elle les rend bienportans et gais; elle leur donne de l'embonpoint, et de bonnes couleurs." *Descrip. de tout. les Nat. de l'Emp. Russ. t. 2. p. 118.*

they are overcharged, still more debilitated; may not a substance of easy digestion, which at once strengthens the stomach and nourishes the body, become a powerful remedy in all such cases?

AND if acute diseases, especially of the febrile kind, are frequently attended with symptoms of weakness and putridity, may it not be found, from its antiseptic and tonic powers, to be an useful corrector of the one, and restorative from the other?

MAY not the sudden change it produced, in the *first* case, in the state of the patient's feelings, and especially of his sleep, point it out as of use in all cases of excessive irritability?

MAY not the effect it had in restoring his stomach to its functions, recommend it in dyspepsia? And may not the vigour and plumpness which ensued from its use, indicate it in cases even of confirmed atrophy?

HAVE we not reason to believe, that it may be used to advantage in the cure of nervous disorders in general, from the manner in which it operated in the *second* case? And in the incipient, perhaps even in the advanced stages of phthisis, from the rapid and effectual change it occasioned in the pulmonary symptoms of the *third*?

AND may not its efficacy in the *fourth* case, encourage us to employ it in all cases of suppuration or ulcer, in which the body is threatened with hectic fever?

WHETHER all these questions can be answered in the affirmative, must be determined by future experience; and, if they should, perhaps the scarcity of mares milk in this country would greatly circumscribe its utility.

HENCE enquiries will naturally be made, whether other species of milk admit of a similar vinous fermentation, and what proportion of spirit they contain. As these have never been the object, however, of my attention, I will here give the substance
of

what I have been able to learn from others respecting that which is the most common, the milk of cows.

Dr PALLAS*, in the work above quoted, says, that cows milk is also susceptible of the vinous fermentation, and that the Tartars prepare a wine from it in winter, when mares milk fails them; that the wine prepared from cows milk, they call *Airen*; but that they always prefer *Koumifs* when it can be got, as it is more agreeable, and contains a greater quantity of spirit; that *Koumifs* on distillation yields of a weak spirit one third, but that *Airen* yields only two ninth parts of its whole quantity; which spirit they call *Arika*.

THIS account is confirmed by OSERETSKOWSKY, a Russian †, who accompanied LEPECHIN, and other academicians, in their travels through Siberia and Tartary. He published lately a Dissertation on the ardent spirit to be obtained from cows milk.

FROM his experiments, it appears, that cows milk may be fermented with, or even without, souring, provided sufficient time and agitation be employed; that no spirit could be produced from any one of its constituent parts taken separately, nor from any two of them, unless inasmuch as they were mixed with some part of the third; that the milk, with all its parts in their natural proportion, was the most productive of it; that the closer it was kept, or, which is the same thing, the more difficultly the fixed air is allowed to escape during the fermentation, (care being taken, however, that we do not endanger the bursting of the vessel), the more spirit is obtained. He also informs us, that it had a sourer smell before than after agitation; that the quantity of spirit was increased, by allowing the fermented liquor to repose for some time before distillation; that from six pints of milk, fermented in a close vessel, and thus set to repose, he obtained three ounces of ardent spirit, of which one was consumed

* Physikalisch. Reise durch verschied. provintz. des Russisch. Reichs, t. 1. p. 316. et 317.

† Specim. inaug. de Spir. Ardent. ex lact. Bub. Argentorat. 1778.

consumed in burning; but that from the same quantity of the same milk, fermented in an open vessel, he could scarcely obtain one ounce.

THESE particulars of the fermentation of mares and cows milk are an interesting addition to the facts concerning fermentation in general; a subject so very obscure and imperfectly understood, that I shall not hazard any remarks on it. My principal intention was, to point out to physicians what appears to me a powerful means which may be employed by them on many occasions in the cure of diseases.

VII. *An IMPROVEMENT of the Method of correcting the OBSERVED DISTANCE of the MOON from the SUN or a FIXED STAR. By the Rev. Mr THOMAS ELLIOT, Minister of the Gospel at Cavers.*

[Communicated by Mr ROBISON, General Secretary, Aug. 2. 1784.]

P R O B L E M.

HAVING the apparent distance of the Moon's centre from a fixed Star, or from the centre of the Sun, together with the apparent altitudes of their centres, to find the true distance.

S O L U T I O N.

THE difference between the apparent and true altitudes, and the angles which the Moon and Star make with the zenith and each other, must be known before the several corrections of distance are computed.

THE difference between the apparent and true altitude of a Star is the refraction in altitude, given p. 2. of *Tables requisite to be used with the nautical ephemeris*. If the distance was taken from the Sun in place of a Star, his refraction may be corrected by subtracting from it his parallax in altitude, given at the end of the *requisite tables*, and the difference used instead of the refraction of a Star; and, if great accuracy is required, the mean refractions may be corrected by the barometer and thermometer, according to Dr BRADLEY's rule, p. 130. *requisite tables*.

To find the difference between the apparent and true altitude of the Moon, the horizontal parallax, given in the ephemeris for the preceding noon or midnight, must be reduced to the time of observation, according to the instructions in the *requisite*

site tables. Then to the arithmetical complement of the logarithmic cosine of the moon's altitude, add the proportional logarithm of the reduced horizontal parallax, the sum will be the proportional logarithm of the parallax in altitude; from the parallax in altitude subtract the refraction in altitude, and the remainder will be the difference between the apparent and true altitude of the moon; which call the corrected parallax.

IF, at the time of observation, the moon and star are in the same vertical, which may sometimes happen in low latitudes, no angles are to be found. They will be in the same vertical, and on the same side of the zenith, if the apparent distance and lesser altitude together are equal to the greater altitude. In which case, the sum of the corrected parallax and star's refraction, added to the apparent distance when the moon's altitude is greatest, or subtracted from it when the moon's altitude is least, will give the true distance. They will also be on the same vertical, but on opposite sides of the zenith, if the apparent distance, added to the sum of the altitudes, is equal to 180° . In this case, the difference of the corrected parallax and star's refraction, *subtracted* from the apparent, will give the true distance; except when the moon is so near the zenith, that the corrected parallax becomes less than the star's refraction, in which case the difference must be *added* to the apparent distance.

IF the apparent altitudes are equal, the angles at the moon and star will also be equal, and may both be found at once, by adding the logarithmic tangent of the common altitude to the logarithmic tangent of half the apparent distance, the sum, rejecting radius, will be the logarithmic cosine of each of the angles at the moon and star, and each of them will be acute, or less than 90° .

WHEN the altitudes are unequal, the angles may be found by the following method:

To

To the logarithmic cotangent of half the sum of the apparent altitudes add the logarithmic tangent of half their difference, and from the sum subtract the logarithmic tangent of half the apparent distance, the remainder will be the logarithmic tangent of a 1st arc.

THE sum of arc 1st and half the apparent distance, will be a 2d arc.

THE difference of arc 1st and half the apparent distance, will be a 3d arc.

To the log. tangent of arc 3d add the log. tangent of the greater altitude, the sum, rejecting radius, will be the log. cosine, either of the angle itself at the higher object, between the other object and the zenith, or of its supplement to 180° , as arc 1st is less or greater than the half distance. As the application of the *first* and *third* corrections depends on the quality of the angles, it must be observed, that, if arc 1st is less than the half distance, the angle *itself* will be found, and will be acute; but if arc 1st is greater than the half distance, the angle found will be the *supplement* of the angle at the higher object to 180° , and the angle itself will be obtuse, or greater than 90° . Nevertheless, if the greater altitude is that of the Moon, the cosine thus found is to be used in computing the *first* correction of distance.

To the log. tangent of arc 2d add the log. tangent of the lesser altitude, the sum, rejecting radius, will be the log. cosine of the angle at the lower object, between the other object and the zenith, and will always be acute.

THESE two angles being known, the several corrections of distance will be found as follows:

1. To the arithmetical complement of the log. cosine of the angle at the Moon, add the proportional logarithm of the corrected parallax, the sum will be the proportional logarithm of the *first* correction, which is to be added to the apparent di-

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stance

stance if the angle at the Moon is obtuse, and subtracted if acute.

2. ADD together the proportional logarithms of the sum and difference of the corrected parallax and *first* correction of distance, and take their sum, which, for distinction, call the rectangle logarithm. To the rectangle logarithm, add the constant logarithm 1.5819, and the log. tangent of the distance *once* corrected, the sum of these three logarithms, rejecting ten from the index, will be the proportional logarithm of the *second* correction of distance, which is always to be added, except the distance is more than 90° , in which case it is to be subtracted.

To half the rectangle logarithm add the log. sine of the distance *twice* corrected, the sum, rejecting ten from the index, will be the proportional logarithm of a correction, to be subtracted from the angle at the Star, or to be added to its supplement.

3. To the arithmetical complement of the log. cosine of the corrected angle at the Star, add the proportional logarithm of the Star's refraction, the sum will be the proportional logarithm of the *third* correction, which (contrary to the *first*) is to be subtracted from the distance, if the angle at the Star is obtuse, and added if acute.

THESE three corrections, applied as above directed, will give the true distance of the Moon from the Sun or a fixed Star.

THERE is, indeed, a *second* correction for the Star's refraction, similar to the *second* correction for parallax; but in most cases it will not amount to $1''$; and even when the Star's altitude is only 5° , and the distance only 20° , it will not exceed $2''\frac{1}{2}$: It may, therefore, generally be omitted. But, if it is desired, this correction may be found in the same manner as the *second*.

4. ADD together the proportional logarithms of the sum and difference of the Star's refraction and *third* correction of distance, the constant logarithm 1.5819, and the log. tangent of the distance *thrice* corrected, the sum of these four logarithms, rejecting

rejecting ten from the index, will be the proportional logarithm of a *fourth* correction, which, added to the distance, thrice corrected, will give the true distance.

THE following method of finding the angles at the Moon and Star will perhaps be more familiar to some; as it is the same with the method commonly used to find the apparent time from the angle at the pole between the meridian and the Sun or a fixed Star; and though it is not quite so concise as the former, it has this advantage, that it gives both the angles without any ambiguity. When this *second* method is used, the logarithms should be taken to at least five places of figures, besides the index.

1. *To find the Angle at the Moon.*

ADD together the apparent zenith distance of the Star, the apparent zenith distance of the Moon, and the apparent distance of the Star from the Moon's centre; take their sum, half their sum, and the difference between the half sum and the zenith distance of the Star; then add together the arithmetical complements of the log. fines of the Moon's zenith distance and the apparent distance of the objects, and the log. fines of the half sum, and the difference between the half sum and the zenith distance of the Star. Half the sum of these four logarithms will be the log. cofine of half the angle required, which being doubled, will give the angle at the Moon between the zenith and the Star.

2. *To find the Angle at the Star.*

ADD together the zenith distances of the Moon and Star, and the apparent distance, and take their sum and half sum as before; but now take the difference between the half sum and the zenith distance of the Moon; then add together the arithmetical complements of the log. fines of the Star's zenith distance and the distance of the objects, and the log. fines of the

B b 2

half

half sum and the difference between the half sum and the zenith distance of the Moon. Half the sum of these four logarithms will be the log. cosine of half the angle, which, being doubled, will give the angle at the Star between the zenith and the Moon.

THE angles being found, the several corrections of distance are to be computed and applied according to the rules already given.

INVESTIGATION.

IN the spherical triangle MZS , let Z represent the zenith, M the apparent place of the Moon, S the apparent place of the Star, and MS the apparent distance of the Star from the Moon's centre. Let Zp be a perpendicular arc let fall from Z upon MS , produced if necessary, and let m be the middle of the base, so that Mm or Sm be equal to half the distance of the objects. If the zenith distances MZ and SZ are equal, the triangle will be isosceles, and the angles ZMS and ZSM will also be equal, and Zp will fall upon MS in m ; but if MZ and SZ are unequal, Zp will fall upon MS at some distance from m , either within or without the triangle, and the angles ZMS and ZSM will also be unequal. Then (by case 11. *obliq. spher. triang.*) pm will be the *first* arc, equal to the distance between the perpendicular and the middle of the base; half the base added to pm will be the *second* arc, equal to the distance of the perpendicular from the lower object; and the difference between half the base and pm will be arc *third*, equal to the distance of the perpendicular from the higher object. It is evident that, when pm is less than half the base, the perpendicular must fall within the triangle, and the angles, both at M and S must be acute; on the contrary, when pm is greater than half the base, the perpendicular must fall without the triangle, and the angle at that object which is next the perpendicular will be obtuse; and

ZSp

ZSp (fig. 1.) will be the supplement of ZSM , and ZMP (fig. 2.) will be the supplement of ZMS to 180° .

Zp being perpendicular to MS , the two triangles ZpM and ZpS will both be right-angled at p . The hypotenuses MZ and SZ are the zenith distances of the objects, or the complements of their apparent altitudes, and the legs MP or SP are the *second* or *third* arches. Then (by case 6. *right ang. spher. triang.*) the cotangent of the hypotenuse, or, which is the same, the tangent of the altitude, multiplied by the tangent of the leg, and divided by radius, gives the cosine of the angle between the hypotenuse and that leg; by which the angles ZMS and ZSM will be found.

THE other method of finding the angles is prop. 17. *spher. triangles*, prefixed to SHERWIN's Tables, revised by CLARK; and is the same with that given in the *requisite tables* for finding the horary angle.

THE sine of the horizontal parallax being to the sine of the parallax in altitude, as radius to the sine of the zenith distance, (KEIL's *Astron. lect.* 21.) the sine of the horizontal parallax, multiplied by the sine of the zenith distance, or, which is equal to it, by the cosine of the altitude, and divided by radius, will give the sine of the parallax in altitude.

LET Lq represent the parallax in altitude, and Mq the refraction in altitude, then Mq subtracted from Lq will leave LM the corrected parallax, equal to the difference between the apparent and true altitude of the Moon. Let SR be equal to the Star's refraction; then L will be the true place of the Moon, and R the true place of the Star, and LR the true distance. Let La be a perpendicular arc from L , falling upon MS , produced if necessary, and let Rc be a perpendicular arc from R , falling upon LS , produced if necessary with the distance LS draw Lb , and with the distance LR draw Rd ; then LR and Ld being radii from the same centre, or rather arches from L , as a pole, to the same parallel, will be equal to one another; and,
for

for the same reason, SL and Sb will be equal to one another: Then the several corrections and corrected distances will be as follows:

- 1st correction Ma , distance once corrected Sa .
- 2^d correction ab , distance twice corrected Sb , equal to SL .
- 3^d correction Sc , distance thrice corrected Lc .
- 4th correction cd , distance four times corrected Ld , equal to LR the true distance. Radius 1.

THE *first* correction Ma is equal ML multiplied by the cosine of LMS .

THE arc La being perpendicular to MS , the two triangles MaL and SaL will both be right-angled at a . It has been proved, that SL and Sb are equal; therefore ab , which is the *second* correction, will be the difference between SL and Sa ; and is found by the following proportion: The rectangle under the tangents of half the sum, and half the difference of LM , the hypotenuse, and aM , one of the legs, is equal to the square tangent of half La , the other leg; and the rectangle, under the tangents of half the sum and half the difference of SL and Sa , is also equal to the square tangent of half La , (HEATH'S *Astron.* p. 330.) Hence the square tangent of half La , divided by the tangent of half the sum of SL and Sa , will be equal to the tangent of half the difference of SL and Sa , that is, to the tangent of half ab ; and twice the square tangent of half La , divided by the tangent of half the sum of SL and Sa , will be equal to the tangent of ab . The proper divisor, therefore, for finding this *second* correction justly, is the tangent of Sa increased by half ab . But, as this will not make the correction $\frac{1}{4}''$ less than when Sa is made the divisor, supposing the distance not under 20° , it was thought needless to mention it in the precepts.

IN such a small triangle, where the corrected parallax is the hypotenuse, which can never exceed $56\frac{1}{2}'$, the difference between the arcs themselves and their sines or tangents is so very inconsiderable, that they may be taken indifferently for one another

ther, without any sensible error ; and, by this means, the calculator may avail himself of that convenient and useful table of the proportional logarithms, and save a great deal of trouble in making proportions for seconds. When the arcs themselves are taken instead of the tangents of the arcs, it will shorten the operation, and the result will be the same, if half the rectangle under the sum and difference of LM and aM is substituted for twice the rectangle under half the sum and half the difference of LM and aM ; each of them is equal to half the square of La , or twice the square of half La , and half the square of La , divided by the tangent of half the sum of SL , and Sa is equal to ab .

WHAT is called the rectangle logarithm is the proportional logarithm of the square of La ; its half is the proportional logarithm of La , and La , divided by the sine of LS , is equal to the angle LSa , which being subtracted from ZSM , leaves ZSL , equal to the opposite angle dSR , fig. 2. ; or, when the angle at the Star is obtuse, as in fig. 1. the angle pSi , equal to the opposite angle LSa , being added to the supplement of the angle at the Star, makes the angle ZSi equal to the opposite angle LSR or dSR , whence the remaining corrections are found in parts of the arc Ld .

THE *third* correction Sc is equal to SR , multiplied by the cosine of cSR .

THE *fourth* correction cd is the difference between Lc and LR , and Rc being perpendicular to Ld , makes the triangles ScR and LcR right-angled at c , so that cd is found by the same proportion as ab .

VIII. ACCOUNT of a REMARKABLE AGITATION of the
Waters of LOCH TAY: In a Letter from the Reverend
Mr THOMAS FLEMING, Minister of Kenmore, to the Reve-
rend JOHN PLAYFAIR, M. A. F. R. S. EDIN. and now
Professor of Mathematics in the University of EDINBURGH.

[Read by Mr PLAYFAIR, Dec. 6. 1784.]

DEAR SIR,

Kenmore Manse, Nov. 4. 1784.

I DID not return from the excursion on which I was when I had the pleasure to see you at Dundee till last Tuesday night. On my arrival, I found your letter respecting the phænomenon that lately happened in this neighbourhood. Although ill qualified to give you satisfaction upon this subject, I shall, however, comply with your desire, and give you the most accurate account of that phænomenon which I have been able to obtain.

ON Sunday the 12th of September, about nine o'clock in the morning, an unusual agitation was observed in LOCH TAY, near the village of Kenmore. That village stands at the east end of the lake, having the river, which there issues from the lake, on the north side, and a bay, about 160 yards in length and 200 yards in breadth, on the south. The greater part of this bay is very shallow, being generally no more than two or three feet deep; but before it joins the body of the lake, it becomes suddenly very deep. At the extremity of this bay, the water was observed to retire about five yards within its ordinary boundary, and in four or five minutes to flow out again. In this manner, it ebbed and flowed successively three or four times during the space of a quarter of an hour, when, all at once, the water
rushed

rushed from the east and west, in opposite currents, towards a line across the bay, and about the edge of the deep, rose in the form of a great wave, to the height of five feet above the ordinary level, leaving the bottom of the bay dry, to the distance of between 90 and 100 yards from its natural boundary. When the opposite currents met, they made a clashing noise, and foamed; and the stronger impulse being from the east, the wave, after rising to its greatest height, rolled westward, but slowly, diminishing as it went, for the space of five minutes, when it wholly disappeared. As the wave subsided, the water flowed back with some force, and exceeded its original boundary four or five yards; then it ebbcd again about ten yards, and again returned, and continued to ebb and flow in this manner for the space of two hours, the ebbings succeeding each other at the distance of about seven minutes, and gradually lessening till the water settled into its ordinary level.

At the same time that the undulation was observed in the bay on the south side of the village, the river on the north was seen to run back; the weeds at its bottom, which before pointed with the stream, received a contrary direction; and its channel was left dry above twelve feet from either edge. Under the bridge, (which is sixty or seventy yards from the lake), the current failed, and the bed of the river appeared where there had been eighteen inches of water.

DURING the whole time that this phenomenon was observed, the weather was calm. It could barely be perceived, that the direction of the clouds was from N. E. The barometer (as far as I can recollect) stood the whole of that and the preceding day about $29\frac{1}{2}$ inches.

ON the next, and the four succeeding days, an ebbing and flowing was observed nearly about the same time, and for the same length of time, but not at all in the same degree as on the first day. A similar agitation was remarked at intervals, some

C c

days

days in the morning, other days in the afternoon, till the 15th of October, since which time no such thing has been observed.

I HAVE not heard (although I have made particular enquiry) that any motion of the earth was felt in this neighbourhood, or that the agitation of the water was observed any where but about the village of Kenmore.

I HOPE the above account will furnish an answer to most of the questions contained in your letter. If there be any other circumstance about which you wish to have farther information, it will give me pleasure to be able to communicate it. I am,

Dear Sir,

Your most obedient humble servant,

THOMAS FLEMING.

N. B. THE village of Kenmore is situated nearly in the parallel of $56^{\circ}, 35'$, and about 1° west of the meridian of Edinburgh. Loch Tay extends from thence somewhat more than 15 miles W. S. W. Its medium breadth is not much less than a mile, and its depth must be very considerable, if one may judge from the height of the adjacent mountains.

IX. ABSTRACT of a REGISTER of the WEATHER, kept at
Branxholm for Ten Years, ending December 31. 1783.

[Communicated by the Duke of BUCCLEUGH, President, Jan. 3. 1785.]

IN the register from which this abstract is taken, the numbers were marked every day at nine o'clock *A. M.* The quantity of rain was measured by means of a tin-cylinder, guarded by a wooden box, and sunk in the earth, into which the rain was received through a funnel, whereof the area was quadruple that of the cylinder. A gage, which floated on the surface of the water in the cylinder, had a rod fixed to it, divided into inches and tenths, which passed through the pipe of the funnel. The fourth part of the rise of this index marked the depth of rain which had fallen since the last observation, and these observations were generally made once in twenty-four hours.

BRANXHOLM is situated on the Tiviot, about ten miles from its source, and near the ridge from which the country declines toward the east and west seas. It is about forty-four miles S. W. by W. of Berwick, and thirty-five N. E. of the head of the Solway frith.

ABSTRACT for 1774.

Month.	Rain.	Barom.	Therm.	Wind, Ely Wly	
				Days.	
Jan.	.300	29.284		23	8
Feb.	3.425	28.900		5	23
March,	.750	29.380		23	8
April,	1.900	29.080		12	18
May,	3.450	29.220		28	3
June,	3.600	29.100		6	24
July,	2.450	29.213		31	0
Aug.	4.500	29.184		7	24
Sept.	3.350	29.083		20	10
Oct.	.950	29.700		7	24
Nov.	2.250	29.200		14	16
Dec.	2.325	29.361		9	22
Rain, Mean,	29.250	29.225		185	180

ABSTRACT for 1775.

Month.	Rain.	Barom.	Therm.	Wind, Ely Wly	
				Days.	
Jan.	5.350	29.040	36.00	13	18
Feb.	4.600	28.800	38.00	3	25
March,	2.450	28.150	40.30	5	26
April,	.700	28.563	46.30	4	26
May,	1.475	29.353	51.36	5	26
June,	1.500	29.233	57.05	19	11
July,	3.573	29.074	58.50	9	22
Aug.	4.425	29.000	56.51	4	27
Sept.	4.300	29.040	53.50	11	19
Oct.	4.550	29.000	44.16	3	28
Nov.	4.000	29.100	33.90	16	14
Dec.	1.650	29.122	34.65	7	24
Rain, Mean,	38.573	28.956	45.85	99	266

ABSTRACT for 1776.

Month.	Rain.	Barom.	Therm.	Wind, Ely Wly	
				Days.	
Jan.*	Snowlies	29.070	26.00	21	10
Feb.	6.070	28.500	34.72	8	21
March,	1.375	29.140	39.00	11	20
April,	1.550	29.300	45.40	5	25
May,	.725	29.333	48.00	12	19
June,	1.375	29.445	54.70	6	24
July,	3.425	29.303	58.55	4	27
Aug.	2.900	29.120	56.00	5	26
Sept.	2.750	29.150	50.30	9	21
Oct.	1.800	29.230	45.00	9	22
Nov.	2.450	29.050	38.00	11	19
Dec.	1.875	29.130	36.06	10	21
Rain, Mean,	26.295	29.147	44.31	111	255

ABSTRACT for 1777.

Month.	Rain.	Barom.	Therm.	Wind, Ely Wly	
				Days.	
Jan.	1.875	29.084	30.90	20	11
Feb.	3.383	29.171	31.43	17	11
March,	1.550	29.032	38.00	9	22
April,	2.825	29.263	40.00	17	13
May,	1.800	29.032	49.40	11	20
June,	2.450	29.180	51.90	10	20
July,	2.050	29.161	54.45	15	16
Aug.	2.450	29.180	57.00	4	27
Sept.	.750	29.283	53.90	2	28
Oct.	7.400	29.000	45.90	14	17
Nov.	2.750	29.100	39.00	4	26
Dec.	.250	29.110	34.23	17	14
Rain, Mean,	26.533	29.133	43.84	140	225

ABSTRACT

* The height of the rain-gage, when the snow melted on the 17th of February, is included in the sum of that month.

ABSTRACT for 1778.

Month.	Rain.	Barom.	Therm.	Wind, Ely Wly
				Days.
Jan.	2.200	29.200	32.550	8 23
Feb.	.600	29.000	34.650	8 20
March,	6.200	29.371	35.800	20 11
April,	1.925	28.323	42.500	15 15
May,	2.200	29.300	52.160	6 25
June,	2.400	29.230	57.270	4 26
July,	5.500	29.130	59.000	8 23
Aug.	1.775	29.320	56.320	8 23
Sept.	2.200	29.300	50.066	10 20
Oct.	6.250	28.950	40.700	21 10
Nov.	4.400	28.890	38.500	16 14
Dec.	4.350	29.000	39.130	8 23
Rain, Mean,	36.400	29.084	44.888	132 233

ABSTRACT for 1779.

Month.	Rain.	Barom.	Therm.	Wind, Ely Wly
				Days
Jan.	1.397	29.500	33.770	11 20
Feb.	1.700	29.700	43.700	00 28
March,	.250	29.350	41.900	12 19
April,	2.650	28.160	42.600	1 29
May,	3.025	29.100	49.000	12 19
June,	2.075	29.280	55.200	22 8
July,	4.975	29.150	61.400	10 21
Aug.	1.050	29.300	59.800	14 17
Sept.	4.975	29.045	52.770	2 28
Oct.	4.450	29.126	46.100	6 25
Nov.	1.175	28.900	38.000	8 22
Dec.	3.970	28.887	30.030	14 17
Rain, Mean,	31.692	29.123	46.190	112 253

ABSTRACT for 1780.

Month.	Rain.	Barom.	Therm.	Wind, Ely Wly
				Days.
Jan.	Frost.	29.160	25.605	20 11
Feb.	1.250	29.000	32.290	10 19
March,	2.950	29.000	42.613	1 30
April,	2.500	28.900	40.700	20 10
May,	4.025	29.090	50.226	4 27
June,	2.100	29.213	55.000	8 22
July,	2.050	29.280	58.355	9 22
Aug.	.250	29.430	59.000	21 10
Sept.	3.350	29.000	54.900	15 15
Oct.	4.700	29.230	44.260	11 20
Nov.	1.975	28.180	34.600	10 20
Dec.	.350	29.530	35.700	10 21
Rain, Mean,	25.500	29.085	44.445	139 227

ABSTRACT for 1781.

Month.	Rain.	Barom.	Therm.	Wind, Ely Wly
				Days.
Jan.	1.300	29.142	32.300	15 16
Feb.	3.600	28.920	38.000	4 24
March,	.200	29.445	41.580	7 24
April,	1.850	29.100	44.500	9 21
May,	1.475	29.355	49.540	20 11
June,	2.000	29.200	55.130	21 9
July,	1.700	29.440	60.640	14 17
Aug.	6.250	29.100	58.000	15 16
Sept.	1.125	29.160	52.560	10 20
Oct.	.950	29.360	46.200	1 30
Nov.	4.250	29.000	38.000	7 23
Dec.	4.600	29.000	35.450	13 18
Rain, Mean,	29.300	29.185	46.000	136 229

ABSTRACT

ABSTRACT for 1782.

Month.	Rain.	Barom.	Therm.	Wind, Ely Wly	
				Days	
Jan.	7.450	29.900	36.000	5	26
Feb.	2.400	29.214	31.643	18	10
March,	3.850	28.900	35.260	13	18
April,	1.900	29.100	38.600	27	3
May,	5.500	28.960	45.562	15	16
June,	1.650	29.250	55.500	5	25
July,	1.750	29.194	58.226	8	23
Aug.	3.700	28.300	54.000	5	26
Sept.	4.700	29.166	49.333	12	28
Oct.	3.150	29.300	41.500	14	17
Nov.	.800	28.220	32.466	19	11
Dec.	1.350	29.226	33.260	13	18
Rain. Mean.	38.200				
		29.061	42.612	154	211

ABSTRACT for 1783.

Month.	Rain.	Barom.	Therm.	Wind, Ely Wly	
				Days	
Jan.	3.025	28.700	34.000	5	26
Feb.	3.650	28.920	35.800	12	16
March,	1.700	29.026	35.000	17	14
April,	.100	29.447	46.433	12	18
May,	1.525	29.210	47.322	12	19
June,	2.300	29.137	54.100	12	18
July,	3.750	29.245	62.450	8	23
Aug.	2.700	29.200	56.600	13	18
Sept.	3.775	28.987	52.800	7	23
Oct.	4.450	29.074	45.000	0	31
Nov.	3.700	29.154	37.330	10	20
Dec.	1.050	29.184	33.700	17	14
Rain. Mean.	31.725				
		29.107	45.045	125	240

ABSTRACT for all the preceding Years.

Year.	Rain,	Barom.	Therm.	Wind, Ely Wly	
				Days	
1774,	29.250	29.225		185	180
1775,	38.573	28.956	45.8500	99	266
1776,	26.295	29.147	44.3100	111	225
1777,	29.533	29.133	43.8400	140	225
1778,	36.400	29.035	44.8880	132	233
1779,	31.692	29.125	46.1900	112	253
1780,	25.500	29.085	44.4450	139	227
1781,	29.300	29.185	46.0000	136	229
1782,	38.200	29.061	42.6070	154	211
1783,	31.725	29.107	45.0449	125	240
Medium of 10 Years, Ditto, 9 Years	31.648	29.106	44.7930	133.3	231.9

COMPARATIVE

COMPARATIVE VIEW of the Depth of Rain at Branhholm, Dalkeith
and Langholm, for five Years.

THE Rain at all these Places was measured as has been described above.

Month.	1773.			1774.			1775.			1776.			1777.		
	Dalk.	Branx.	Lang.	Dalk.	Branx.	Lang.	Dalk.	Branx.	Lang.	Dalk.	Branx.	Lang.	Dalk.	Branx.	Lang.
Jan.	3.250	4.100	5.200	4.400	0.300	1.150	3.375	5.350	7.200	0.700	Snow lies		1.025	1.875	0.200
Feb.	1.000	2.375	2.500	2.150	3.425	3.200	2.200	4.600	5.100	3.650	6.870	5.475	0.975	3.383	3.500
March,	1.050	1.350	1.600	0.375	0.750	0.525	0.125	2.450	3.800	1.325	1.375	2.600	1.825	1.550	1.000
April,	2.400	3.200	3.900	1.200	1.900	3.275	0.400	0.700	1.200	0.925	1.550	0.225	3.525	2.825	4.500
May,	1.525	2.000	1.200	1.600	3.450	2.625	1.250	1.475	0.500	0.400	0.725	0.375	0.650	1.800	3.250
June,	1.600	1.125	1.000	3.100	3.600	3.025	0.300	1.500	0.400	1.775	1.375	0.625	1.800	2.450	4.000
July,	1.200	0.752	1.100	1.600	2.450	5.000	6.175	3.573	3.000	2.900	3.425	3.125	2.350	2.050	2.325
Aug.	1.800	1.850	3.425	3.675	4.500	4.450	3.050	4.425	6.000	1.900	2.900	5.225	1.575	2.450	4.250
Sept.	4.425	4.600	8.300	2.350	3.350	5.975	2.825	4.300	4.500	1.675	2.750	5.500	1.750	0.750	2.150
Oct.	1.475	6.125	6.125	1.175	0.950	0.875	6.125	4.550	2.700	1.300	1.800	4.425	4.600	7.400	6.750
Nov.	3.175	1.550	2.900	1.225	2.250	2.100	3.450	4.000	2.200	1.200	2.450	4.225	1.800	2.750	4.650
Dec.	2.575	3.625	1.600	2.125	2.325	2.205	0.275	1.650	2.700	1.900	1.875	2.361	0.950	0.250	0.375

Dalkeith lies 44 Miles N. by E; and Langholm 20 S. by W. from Branhholm.

RESULT of the preceding Comparifon.

Year.	Dalkeith.	Branxholm.	Langholm.
1773,	25.473	32.652	38.850
1774,	27.925	29.250	34.405
1775,	29.550	38.573	39.300
1776,	20.650	26.295	34.161
1777,	22.025	29.533	36.950
Medium	25.1246	31.2606	36.7333

X. THEORY of the EARTH; or an INVESTIGATION of the
Laws observable in the Composition, Dissolution, and Restoration
of Land upon the Globe. By JAMES HUTTON, M. D.
F. R. S. EDIN. and Member of the Royal Academy of Agriculture at PARIS.

[Read March 7. and April 4. 1785.]

P A R T. I.

Prospect of the Subject to be treated of.

WHEN we trace the parts of which this terrestrial system is composed, and when we view the general connection of those several parts, the whole presents a machine of a peculiar construction by which it is adapted to a certain end. We perceive a fabric, erected in wisdom, to obtain a purpose worthy of the power that is apparent in the production of it.

WE know little of the earth's internal parts, or of the materials which compose it at any considerable depth below the surface. But upon the surface of this globe, the more inert matter is replenished with plants, and with animal and intellectual beings.

WHERE so many living creatures are to ply their respective powers, in pursuing the end for which they were intended, we are not to look for nature in a quiescent state; matter itself must be in motion, and the scenes of life a continued or repeated series of agitations and events.

THIS globe of the earth is a habitable world; and on its fitness for this purpose, our sense of wisdom in its formation

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must

must depend. To judge of this point, we must keep in view, not only the end, but the means also by which that end is obtained. These are, the form of the whole, the materials of which it is composed, and the several powers which concur, counter-act, or balance one another, in procuring the general result.

THE form and constitution of the mass are not more evidently calculated for the purpose of this earth as a habitable world, than are the various substances of which that complicated body is composed. Soft and hard parts variously combine, to form a medium consistence adapted to the use of plants and animals; wet and dry are properly mixed for nutrition, or the support of those growing bodies; and hot and cold produce a temperature or climate no less required than a soil. Inasmuch, that there is not any particular, respecting either the qualities of the materials, or the construction of the machine, more obvious to our perception, than are the presence and efficacy of design and intelligence in the power that conducts the work.

IN taking this view of things, where ends and means are made the object of attention, we may hope to find a principle upon which the comparative importance of parts in the system of nature may be estimated, and also a rule for selecting the object of our enquiries. Under this direction, science may find a fit subject of investigation in every particular, whether of *form*, *quality*, or *active power*, that presents itself in this system of motion and of life; and which, without a proper attention to this character of the system, might appear anomalous and incomprehensible.

IT is not only by seeing those general operations of the globe which depend upon its peculiar construction as a machine, but also by perceiving how far the particulars, in the construction of that machine, depend upon the general operations of the globe, that we are enabled to understand the constitution of this earth as a thing formed by design. We shall thus also be led to acknowledge an order, not unworthy of Divine wisdom, in

a subject which, in another view, has appeared as the work of chance, or as absolute disorder and confusion.

To acquire a general or comprehensive view of this mechanism of the globe, by which it is adapted to the purpose of being a habitable world, it is necessary to distinguish three different bodies which compose the whole. These are, a solid body of earth, an aqueous body of sea, and an elastic fluid of air.

It is the proper shape and disposition of these three bodies that form this globe into a habitable world; and it is the manner in which these constituent bodies are adjusted to each other, and the laws of action by which they are maintained in their proper qualities and respective departments, that form the Theory of the machine which we are now to examine.

LET us begin with some general sketch of the particulars now mentioned.

1st, THERE is a central body in the globe. This body supports those parts which come to be more immediately exposed to our view, or which may be examined by our sense and observation. This first part is commonly supposed to be solid and inert; but such a conclusion is only mere conjecture; and we shall afterwards find occasion, perhaps, to form another judgment in relation to this subject, after we have examined strictly, upon scientific principles, what appears upon the surface, and have formed conclusions concerning that which must have been transacted in some more central part.

2^{dly}, WE find a fluid body of water. This, by gravitation, is reduced to a spherical form, and by the centrifugal force of the earth's rotation, is become oblate. The purpose of this fluid body is essential in the constitution of the world; for, besides affording the means of life and motion to a multifarious race of animals, it is the source of growth and circulation to the organized bodies of this earth, in being the receptacle of the rivers, and the fountain of our vapours.

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3^{dly},

3dly, WE have an irregular body of land, raised above the level of the ocean. This, no doubt, is the smallest portion of the globe; but it is the part to us by far most interesting. It is upon the surface of this part that plants are made to grow; consequently, it is by virtue of this land that animal life, as well as vegetation, is sustained in this world.

Lastly, WE have a surrounding body of atmosphere, which completes the globe. This vital fluid is no less necessary in the constitution of the world than are the other parts; for there is hardly an operation upon the surface of the earth, that is not conducted or promoted by its means. It is a necessary condition for the sustenance of fire; it is the breath of life to animals; it is at least an instrument in vegetation; and while it contributes to give fertility and health to things that grow, it is employed in preventing noxious effects from such as go into corruption. In short, it is the proper means of circulation for the matter of this world, by raising up the water of the ocean, and pouring it forth upon the surface of the earth.

SUCH is the mechanism of the globe; let us now mention some of those powers by which motion is produced, and activity procured to the mere machine.

FIRST, There is the progressive force, or moving power, by which this planetary body, if solely actuated, would depart continually from the path which it now pursues, and thus be for ever removed from its end, whether as a planetary body, or as a globe sustaining plants and animals, which may be termed a living world.

BUT this moving body is also actuated by gravitation, which inclines it directly to the central body of the sun. Thus it is made to revolve about that luminary, and to preserve its path.

It is also upon the same principles, that each particular part upon the surface of this globe, is alternately exposed to the influence of light and darkness, in the diurnal rotation of the earth, as well as in its annual revolution. In this manner are produced

produced the vicissitudes of night and day, so variable in the different latitudes from the equator to the pole, and so beautifully calculated to equalize the benefits of light, so variously distributed in the different regions of the globe.

GRAVITATION and the *vis incita* of matter thus form the first two powers distinguishable in the operations of our system, and wisely adapted to the purpose for which they are employed.

WE next observe the influence of light and heat, of cold and condensation. It is by means of these two powers that the various operations of this living world are more immediately transacted; although the other powers are no less required, in order to produce or modify these great agents in the œconomy of life, and system of our changing things.

WE do not now enquire into the nature of those powers, or investigate the laws of light and heat, of cold and condensation, by which the various purposes of this world are accomplished; we are only to mention those effects which are made sensible to the common understanding of mankind, and which necessarily imply a power that is employed. Thus, it is by the operation of those powers that the varieties of season in spring and autumn are obtained, that we are blessed with the vicissitudes of summer's heat and winter's cold, and that we possess the benefit of artificial light and culinary fire.

WE are thus bountifully provided with the necessaries of life; we are supplied with things conducive to the growth and preservation of our animal nature, and with fit subjects to employ and to nourish our intellectual powers.

THERE are other actuating powers employed in the operations of this globe, which we are little more than able to enumerate; such are those of electricity and magnetism.

POWERS of such magnitude or force, are not to be supposed useless in a machine contrived surely not without wisdom; but they are mentioned here chiefly on account of their general effect; and it is sufficient to have named powers, of which the
actual

actual existence is well known, but of which the proper use in the constitution of the world is still obscure.

WE have thus surveyed the machine in general, with those moving powers, by which its operations, diversified almost *ad infinitum*, are performed. Let us now confine our view, more particularly, to that part of the machine on which we dwell, that so we may consider the natural consequences of those operations which, being within our view, we are better qualified to examine.

THIS subject is important to the human race, to the possessor of this world, to the intelligent being Man, who foresees events to come, and who, in contemplating his future interest, is led to enquire concerning causes, in order that he may judge of events which otherwise he could not know.

IF, in pursuing this object, we employ our skill in research, not in forming vain conjectures; and if *data* are to be found, on which Science may form just conclusions, we should not long remain in ignorance with respect to the natural history of this earth, a subject on which hitherto opinion only, and not evidence, has decided: For in no subject is there naturally less defect of evidence, although philosophers, led by prejudice, or misguided by false theory, have neglected to employ that light by which they should have seen the system of this world.

BUT to proceed in pursuing a little farther our general or preparatory ideas. A solid body of land could not have answered the purpose of a habitable world; for a soil is necessary to the growth of plants; and a soil is nothing but the materials collected from the destruction of the solid land. Therefore, the surface of this land, inhabited by man, and covered with plants and animals, is made by nature to decay, in dissolving from that hard and compact state in which it is found below the soil; and this soil is necessarily washed away, by the continual circulation of the water, running from the summits of the mountains towards the general receptacle of that fluid.

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THE heights of our land are thus levelled with the shores; our fertile plains are formed from the ruins of the mountains; and those travelling materials are still pursued by the moving water, and propelled along the inclined surface of the earth. These moveable materials, delivered into the sea, cannot, for a long continuance, rest upon the shore; for, by the agitation of the winds, the tides and currents, every moveable thing is carried farther and farther along the shelving bottom of the sea, towards the unfathomable regions of the ocean.

IF the vegetable soil is thus constantly removed from the surface of the land, and if its place is thus to be supplied from the dissolution of the solid earth, as here represented, we may perceive an end to this beautiful machine; an end, arising from no error in its constitution as a world, but from that destructibility of its land which is so necessary in the system of the globe, in the œconomy of life and vegetation.

THE immense time necessarily required for this total destruction of the land, must not be opposed to that view of future events, which is indicated by the surest facts and most approved principles. Time, which measures every thing in our idea, and is often deficient to our schemes, is to nature endless and as nothing; it cannot limit that by which alone it had existence; and as the natural course of time, which to us seems infinite, cannot be bounded by any operation that may have an end, the progress of things upon this globe, that is, the course of nature, cannot be limited by time, which must proceed in a continual succession. We are, therefore, to consider as inevitable the destruction of our land, so far as effected by those operations which are necessary in the purpose of the globe, considered as a habitable world; and so far as we have not examined any other part of the œconomy of nature, in which other operations and a different intention might appear.

WE have now considered the globe of this earth as a machine, constructed upon chemical as well as mechanical principles,
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by which its different parts are all adapted, in form, in quality, and in quantity, to a certain end; an end attained with certainty or success; and an end from which we may perceive wisdom, in contemplating the means employed.

BUT is this world to be considered thus merely as a machine, to last no longer than its parts retain their present position, their proper forms and qualities? Or may it not be also considered as an organized body? Such as has a constitution in which the necessary decay of the machine is naturally repaired, in the exertion of those productive powers by which it had been formed.

THIS is the view in which we are now to examine the globe; to see if there be, in the constitution of this world, a reproductive operation, by which a ruined constitution may be again repaired, and a duration or stability thus procured to the machine, considered as a world sustaining plants and animals.

IF no such reproductive power, or reforming operation, after due enquiry, is to be found in the constitution of this world, we should have reason to conclude, that the system of this earth has either been intentionally made imperfect, or has not been the work of infinite power and wisdom.

HERE is an important question, therefore, with regard to the constitution of this globe; a question which, perhaps, it is in the power of man's sagacity to resolve; and a question which, if satisfactorily resolved, might add some lustre to science and the human intellect.

ANIMATED with this great, this interesting view, let us strictly examine our principles, in order to avoid fallacy in our reasoning; and let us endeavour to support our attention, in developing a subject that is vast in its extent, as well as intricate in the relation of parts to be stated.

THE globe of this earth is evidently made for man. He alone, of all the beings which have life upon this body, enjoys the whole and every part; he alone is capable of knowing the
nature

nature of this world, which he thus possesses in virtue of his proper right; and he alone can make the knowledge of this system a source of pleasure and the means of happiness.

MAN alone, of all the animated beings which enjoy the benefits of this earth, employs the knowledge which he there receives, in leading him to judge of the intention of things, as well as of the means by which they are brought about; and he alone is thus made to enjoy, in contemplation as well as sensual pleasure, all the good that may be observed in the constitution of this world; he, therefore, should be made the first subject of enquiry.

Now, if we are to take the written history of man for the rule by which we should judge of the time when the species first began, that period would be but little removed from the present state of things. The Mosaic history places this beginning of man at no great distance; and there has not been found, in natural history, any document by which a high antiquity might be attributed to the human race. But this is not the case with regard to the inferior species of animals, particularly those which inhabit the ocean and its shores. We find in natural history monuments which prove that those animals had long existed; and we thus procure a measure for the computation of a period of time extremely remote, though far from being precisely ascertained.

In examining things present, we have data from which to reason with regard to what has been; and, from what has actually been, we have data for concluding with regard to that which is to happen hereafter. Therefore, upon the supposition that the operations of nature are equable and steady, we find, in natural appearances, means for concluding a certain portion of time to have necessarily elapsed, in the production of those events of which we see the effects.

It is thus that, in finding the relics of sea-animals of every kind in the solid body of our earth, a natural history of those animals is formed, which includes a certain portion of time;

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and for the ascertaining this portion of time, we must again have recourse to the regular operations of this world. We shall thus arrive at facts which indicate a period to which no other species of chronology is able to remount.

IN what follows, therefore, we are to examine the construction of the present earth, in order to understand the natural operations of time past; to acquire principles, by which we may conclude with regard to the future course of things, or judge of those operations, by which a world, so wisely ordered, goes into decay; and to learn, by what means such a decayed world may be renovated, or the waste of habitable land upon the globe repaired.

THIS, therefore, is the object which we are to have in view during this physical investigation; this is the end to which are to be directed all the steps in our cosmological pursuit.

THE solid parts of the globe are, in general, composed of sand, of gravel, of argillaceous and calcareous strata, or of the various compositions of these with some other substances, which it is not necessary now to mention. Sand is separated and sized by streams and currents; gravel is formed by the mutual attrition of stones agitated in water; and marly, or argillaceous strata, have been collected, by subsiding in water with which those earthy substances had been floated. Thus, so far as the earth is formed of these materials, that solid body would appear to have been the production of water, winds, and tides.

BUT that which renders the origin of our land clear and evident, is the immense quantities of calcareous bodies which had belonged to animals, and the intimate connection of these masses of animal production with the other strata of the land. For it is to be proved, that all these calcareous bodies, from the collection of which the strata were formed, have belonged to the sea, and were produced in it.

WE find the marks of marine animals in the most solid parts of the earth, consequently, those solid parts have been formed
after

after the ocean was inhabited by those animals, which are proper to that fluid medium. If, therefore, we knew the natural history of those solid parts, and could trace the operations of the globe, by which they had been formed, we would have some means for computing the time through which those species of animals have continued to live. But how shall we describe a process which nobody has seen performed, and of which no written history gives any account? This is only to be investigated, *first*, in examining the nature of those solid bodies, the history of which we want to know; and, *2dly*, In examining the natural operations of the globe, in order to see if there now actually exist such operations, as, from the nature of the solid bodies, appear to have been necessary to their formation.

BUT, before entering more particularly into those points of discussion, by which the question is to be resolved, let us take a general view of the subject, in order to see what it is which science and observation must decide.

IN all the regions of the globe, immense masses are found, which, though at present in the most solid state, appear to have been formed by the collection of the calcareous *exuviae* of marine animals. The question at present is not, in what manner those collections of calcareous relics have become a perfect solid body, and have been changed from an animal to a mineral substance; for this is a subject that will be afterwards considered; we are now only enquiring, if such is truly the origin of those mineral masses.

THAT all the masses of marble or limestone are composed of the calcareous matter of marine bodies, may be concluded from the following facts:

1st, THERE are few beds of marble or limestone, in which may not be found some of those objects which indicate the marine origin of the mass. If, for example, in a mass of marble, taken from a quarry upon the top of the Alps or

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Andes *, there shall be found one cockle-shell, or piece of coral, it must be concluded, that this bed of stone had been originally formed at the bottom of the sea, as much as another bed which is evidently composed almost altogether of cockle-shells and coral. If one bed of limestone is thus found to have been of a marine origin, every concomitant bed of the same kind must be also concluded to have been formed in the same manner.

WE thus shall find the greatest part of the calcareous masses upon this globe to have originated from marine calcareous bodies; for whether we examine marbles, limestones, or such solid masses as are perfectly changed from the state of earth, and are become compact and hard, or whether we examine the soft, earthy, chalky or marly strata, of which so much of this earth is composed, we still find evident proofs, that those beds had their origin from materials deposited at the bottom of the sea; and that they have the calcareous substance which they contain, from the same source as the marbles or the limestones.

2dly, In those calcareous strata, which are evidently of marine origin, there are many parts that are of a sparry structure, that is to say, the original texture of those beds, in such places, has been dissolved, and a new structure has been assumed, which is peculiar to a certain state of the calcareous earth. This change is produced by crystallization, in consequence of a previous state of fluidity, which has so disposed the concreting parts, as to allow them to assume a regular shape and structure proper to that substance. A body, whose external form has been

* " CETTE sommité élevée de 984 toises au dessus de notre lac, et par conséquent de 1172 au dessus de la mer, est remarquable en ce que l'on y voit des fragmens d'huîtres pétrifiées.—Cette montagne est dominée par un rocher escarpé, qui s'il n'est pas inaccessible, est du moins d'un bien difficile accès; il paroît presque entièrement composé de coquillages pétrifiés, renfermés dans un roc calcaire, ou marbre grossier noirâtre. Les fragmens qui s'en détachent, et que l'on rencontre en montant à la Croix de fer, sont remplis de *turbinites* de différentes especes." M. DE SAUSSURE, *Voyage dans les Alpes*, p. 394.

been modified by this process, is called a *crystal*; one whose internal arrangement of parts is determined by it, is said to be of a *sparry structure*; and this is known from its fracture.

3dly, THERE are, in all the regions of the earth, huge masses of calcareous matter, in that crystalline form or sparry state, in which perhaps no vestige can be found of any organized body, nor any indication that such calcareous matter had belonged to animals; but as, in other masses, this sparry structure, or crystalline state, is evidently assumed by the marine calcareous substances, in operations which are natural to the globe, and which are necessary to the consolidation of the strata, it does not appear, that the sparry masses, in which no figured body is formed, have been originally different from other masses, which, being only crystallized in part, and in part still retaining their original form, leave ample evidence of their marine origin.

WE are led, in this manner, to conclude, that all the strata of the earth, not only those consisting of such calcareous masses, but others superincumbent upon these, have had their origin at the bottom of the sea, by the collection of sand and gravel, of shells, of coralline and crustaceous bodies, and of earths and clays, variously mixed, or separated and accumulated. Here is a general conclusion, well authenticated in the appearances of nature, and highly important in the natural history of the earth.

THE general amount of our reasoning is this, that nine tenths, perhaps, or ninety-nine hundredths of this earth, so far as we see, have been formed by natural operations of the globe, in collecting loose materials, and depositing them at the bottom of the sea; consolidating those collections in various degrees, and either elevating those consolidated masses above the level on which they were formed, or lowering the level of that sea.

THERE is a part of the solid earth which we may at present neglect, not, as being persuaded that this part may not also be found

found to come under the general rule of formation with the rest, but as considering this part to be of no consequence in forming a general rule, which shall comprehend almost the whole, without doing it absolutely. This excluded part consists of certain mountains and masses of granite. These are thought to be still older in their formation, and are very rarely, at least, found superincumbent on strata which must be acknowledged as the productions of the sea.

HAVING thus found the greater part, if not the whole, of the solid land to have been originally composed at the bottom of the sea, we may now, in order to form a proper idea of these operations, suppose the whole of this sea-born land to be again dispersed along the bottom of the ocean, the surface of which would rise proportionally over the globe. We would thus have a spheroid of water, with granite rocks and islands scattered here and there. But this would not be the world which we inhabit; therefore, the question now is, how such continents, as we actually have upon the globe, could be erected above the level of the sea.

It must be evident, that no motion of the sea, caused by this earth revolving in the solar system, could bring about that end; for let us suppose the axis of the earth to be changed from the present poles, and placed in the equinoctial line, the consequence of this might, indeed, be the formation of a continent of land about each new pole, from whence the sea would run towards the new equator; but all the rest of the globe would remain an ocean. Some new points might be discovered, and others, which before appeared above the surface of the sea, would be sunk by the rising of the water; but, on the whole, land could only be gained substantially at the poles. Such a supposition as this, if applied to the present state of things, would be destitute of every support, as being incapable of explaining what appears.

BUT

BUT even allowing that, by the changed axis of the earth, or any other operation of the globe, as a planetary body revolving in the solar system, great continents of land could have been erected from the place of their formation, the bottom of the sea, and placed in a higher elevation, compared with the surface of that water, yet such a continent as this could not have continued stationary for many thousand years; nor could a continent of this kind have presented to us, every where within its body, masses of consolidated marble, and other mineral substances, in a state as different as possible from that in which they were, when originally collected together in the sea.

CONSEQUENTLY, besides an operation, by which the earth at the bottom of the sea should be converted into an elevated land, or placed high above the level of the ocean, there is required, in the operations of the globe, a consolidating power, by which the loose materials that had subsided from water, should be formed into masses of the most perfect solidity, having neither water nor vacuity between their various constituent parts, nor in the pores of those constituent parts themselves.

HERE is an operation of the globe, whether chemical or mechanical, which is necessarily connected with the formation of our present continents: Therefore, had we a proper understanding of this secret operation, we might thereby be enabled to form an opinion, with regard to the nature of that unknown power, by which the continents have been placed above the surface of that water wherein they had their birth.

If this consolidating operation be performed at the bottom of the ocean, or under great depths of the earth, of which our continents are composed, we cannot be witnesses to this mineral process, or acquire the knowledge of natural causes, by immediately observing the changes which they produce; but though we have not this immediate observation of those changes of bodies, we have, in science, the means of reasoning from
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distant events; consequently, of discovering, in the general powers of nature, causes for those events of which we see the effects.

THAT the consolidating operation, in general, lies out of the reach of our immediate observation, will appear from the following truth: All the consolidated masses, of which we now enquire into the cause, are, upon the surface of the earth in a state of general decay, although the various natures of those bodies admit of that dissolution in very different degrees*.

FROM every view of the subject, therefore, we are directed to look into those consolidated masses themselves, in order to find principles from whence to judge of those operations by which they had attained their hardness or consolidated state.

It must be evident, that nothing but the most general acquaintance with the laws of acting substances, and with those of bodies changing by the powers of nature, can enable us to set about this undertaking with any reasonable prospect of success; and here the science of Chemistry must be brought particularly to our aid; for this science, having for its object the changes produced upon the sensible qualities, as they are called, of bodies, by its means we may be enabled to judge of that which is possible according to the laws of nature, and of that which, in like manner, we must consider as impossible.

WHATEVER conclusions, therefore, by means of this science, shall be attained, in just reasoning from natural appearances, this must be held as evidence, where more immediate proof cannot be obtained; and, in a physical subject, where things actual are concerned, and not the imaginations of the human mind, this proof will be considered as amounting to a demonstration.

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* STALACTICAL and certain ferruginous concretions may seem to form an exception to the generality of this proposition. But an objection of this kind could only arise from a partial view of things; for the concretion here is only temporary, it is in consequence of a solution, and it is to be followed by a dissolution, which will be treated of in its proper place.

P A R T II.

An Investigation of the Natural Operations employed in consolidating the Strata of the Globe.

THERE are just two ways in which porous or spongy bodies can be consolidated, and by which substances may be formed into masses of a natural shape and regular structure; the one of these is simple *congelation* from a fluid state, by means of cold; the other is *accretion*; and this includes a separatory operation, as well as that by which the solid body is to be produced. But, in whichever of these ways solidity is to be procured, it must be brought about by first inducing fluidity, either immediately by the action of heat, or mediately with the assistance of a solvent, that is, by the operation of solution.

THUS, fire and water may be considered as the general agents in this operation which we would explore. We are, therefore, to consider well, what may be the consequences of consolidation by the one or other of those agents; and what may be their several powers with respect to this operation.

IF we are not informed in this branch of science, we may gaze without instruction upon the most convincing proofs of what we want to attain. If our knowledge is imperfect, we may form erroneous principles, and deceive ourselves in reasoning with regard to those works of nature, which are wisely calculated for our instruction.

THE strata, formed at the bottom of the sea, are to be considered as having been consolidated, either by aqueous solution and crystallization, or by the effect of heat and fusion. If it is in the first of these two ways that the solid strata of the globe have attained to their present state, there will be a certain uniformity observable in the effects; and there will be ge-

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neral laws, by which this operation must have been conducted. Therefore, knowing those general laws, and making just observations with regard to the natural appearances of those consolidated masses, a philosopher, in his closet, should be able to determine, what may, and what may not have been transacted in the bowels of the earth, or below the bottom of the ocean.

LET us now endeavour to ascertain what may have been the power of water, acting under fixed circumstances, operating upon known substances, and conducting to a certain end.

THE action of water upon all different substances is an operation with which we are familiar. We have it in our power to apply water in different degrees of heat for the solution of bodies, and under various degrees of compression; consequently, there is no reason to conclude any thing mysterious in the operations of the globe, which are to be performed by means of water, unless an immense compressing power should alter the nature of those operations. But compression alters the relation of evaporation only with regard to heat, or it changes the degree of heat which water may be made to contain; consequently, we are to look for no occult quality in water acting upon bodies at the bottom of the deepest ocean, more than what can be observed in experiments which we have it in our power to try.

WITH regard again to the effect of time. Though the continuance of time may do much in those operations which are extremely slow, where no change, to our observation, had appeared to take place; yet, where it is not in the nature of things to produce the change in question, the unlimited course of time would be no more effectual, than the moment by which we measure events in our observations.

WATER being the general medium in which bodies collected at the bottom of the sea are always contained, if those masses of collected matter are to be consolidated by solution, it must be by the dissolution of those bodies in that water as a menstruum,

struum, and by the concretion or crystallization of this dissolved matter, that the spaces, first occupied by water in those masses, are afterwards to be filled with a hard and solid substance; but without some other power, by which the water contained in those cavities and endless labyrinths of the strata, should be separated in proportion as it had performed its task, it is inconceivable how those masses, however changed from the state of their first subsidence, should be absolutely consolidated, without a particle of fluid water in their composition.

BESIDES this difficulty of having the water separated from the porous masses which are to be consolidated, there is another with which, upon this supposition, we have to struggle. This is, From whence should come the matter with which the numberless cavities in those masses are to be filled?

THE water in the cavities and interstices of those bodies composing strata, must be in a stagnating state; consequently, it can only act upon the surfaces of those cavities which are to be filled up. But with what are they to be filled? Not with water; they are full of this already: Not with the substance of the bodies which contain that water; this would be only to make one cavity in order to fill up another. If, therefore, the cavities of the strata are to be filled with solid matter, by means of water, there must be made to pass through those porous masses, water impregnated with some other substances in a dissolved state; and the aqueous menstruum must be made to separate from the dissolved substance, and to deposit the same in those cavities through which the solution moves.

By such a supposition as this, we might perhaps explain a partial consolidation of those strata; but this is a supposition, of which the case under consideration does not admit; for in the present case, which is that of materials accumulated at the bottom of the ocean, there is not proper means for separating the dissolved matter from the water included in those enormous masses; nor are there any means by which a circula-

tion in those masses may be formed. In this case, therefore, where the means are not naturally in the supposition, a philosopher, who is to explain the phænomenon by the natural operation of water in this situation, must not have recourse to another agent, still more powerful, to assist his supposition, which cannot be admitted.

THUS, it will appear, that, to consolidate strata formed at the bottom of the sea, in the manner now considered, operations are required unnatural to this place ; consequently, not to be supposed in order to support a hypothesis.

BUT now, instead of enquiring how far water may be supposed instrumental in the consolidation of strata which were originally of a loose texture, we are to consider how far there may be appearances in those consolidated bodies, by which it might be concluded, whether or not the present state of their consolidation has been actually brought about by means of that agent.

IF water had been the menstruum by which the consolidating matter was introduced into the interstices of strata, masses of those bodies could only be found consolidated with such substances as water is capable of dissolving ; and these substances would be found only in such a state as the simple separation of the dissolving water might produce.

IN this case, the consolidation of strata would be extremely limited ; for we cannot allow more power to water than we find it has in nature ; nor are we to imagine to ourselves unlimited powers in bodies, on purpose to explain those appearances, by which we should be made to know the powers of nature. Let us, therefore, attend, with every possible circumspection, to the appearances of those bodies, by means of which we are to investigate the principles of mineralogy, and know the laws of nature.

THE question now before us concerns the consolidating substances of strata. Are these such as will correspond to the dissolving

solving power of water, and to the state in which those substances might be left by the separation of their menstruum? No; far, far from this supposition is the conclusion that necessarily follows from natural appearances.

WE have strata consolidated by calcareous spar, a thing perfectly distinguishable from the stalactical concretion of calcareous earth, in consequence of aqueous solution. We have strata made solid by the formation of fluor, a substance not soluble, so far as we know, by water. We have strata consolidated with sulphureous and bituminous substances, which do not correspond to the solution of water. We have strata consolidated with siliceous matter, in a state totally different from that under which it has been observed, on certain occasions, to be deposited by water. We have strata consolidated by feldspar, a substance insoluble in water. We have strata consolidated by almost all the various metallic substances, with their almost endless mixtures and sulphureous compositions; that is to say, we find, perhaps, every different substance introduced into the interstices of strata which had been formed by subsidence at the bottom of the sea.

IF it is by means of water that those interstices have been filled with those materials, water must be, like fire, an universal solvent, or cause of fluidity, and we must change entirely our opinion of water in relation to its chemical character. But there is no necessity thus to violate our chemical principles, in order to explain certain natural appearances; more especially if those appearances may be explained in another manner, consistently with the known laws of nature.

IF, again, it is by means of heat and fusion that the loose and porous structure of strata shall be supposed to have been consolidated, then every difficulty which had occurred in reasoning upon the power or agency of water is at once removed. The loose and discontinuous body of a stratum may be closed by means of softness and compression; the porous structure of
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the materials may be consolidated, in a similar manner, by the fusion of their substance; and foreign matter may be introduced into the open structure of strata, in form of steam or exhalation, as well as in the fluid state of fusion; consequently, heat is an agent competent for the consolidation of strata, which water alone is not. If, therefore, such an agent could be found acting in the natural place of strata, we must pronounce it proper to bring about that end.

THE examination of nature gives countenance to this supposition, so far as strata are found consolidated by every species of substance, and almost every possible mixture of those different substances; consequently, however difficult it may appear to have this application of heat, for the purpose of consolidating strata formed at the bottom of the ocean, we cannot, from natural appearances, suppose any other cause, as having actually produced the effects which are now examined.

THIS question, with regard to the means of consolidating the strata of the globe, is, to natural history, of the greatest importance; and it is essential in the theory now proposed to be given of the mineral system. It would, therefore, require to be discussed with some degree of precision, in examining the particulars; but of these, there is so great a field, and the subject is so complicated in its nature, that volumes might be written upon particular branches only, without exhausting what might be said upon the subject; because the evidence, though strong in many particulars, is chiefly to be enforced by a multitude of facts, conspiring, in a diversity of ways, to point out one truth, and by the impossibility of reconciling all these facts, except by means of one supposition.

BUT, as it is necessary to give some proof of that which is to be a principle in our reasoning afterwards, I shall now endeavour to generalize the subject as much as possible, in order to answer that end, and, at the same time, to point out the particular method of enquiry.

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THERE are to be found, among the various strata of the globe, bodies formed of two different kinds of substances, *siliceous* bodies, and those which may be termed *fulphureous*. With one or other, or both of those two substances, every different consolidated stratum of the globe will be found so intimately mixed, or closely connected, that it must be concluded, by whatever cause those bodies of siliceous and fulphureous matter had been changed from a fluid to a concreted state, the strata must have been similarly affected by the same cause.

THESE two species of bodies, therefore, the siliceous and the fulphureous, may now be examined, in relation to the causes of their concretion, with a view to determine, what has been the general concreting or consolidating power, which has operated universally in the globe; and particularly to shew, it has not been by means of any fluid solution, that strata in general have been consolidated, or that those particular substances have been crystallized and concreted.

SILICEOUS matter, physically speaking, is not soluble in water; that is to say, in no manner of way have we been enabled to learn, that water has the power of dissolving this matter.

MANY other substances, which are so little soluble in water, that their solubility could not be otherwise detected of themselves, are made to appear soluble by means of siliceous matter; such is feld-spar, one of the component parts of rock-granite.

FELD-SPAR is a compound of siliceous, argillaceous, and calcareous earth, intimately united together. This compound siliceous body being, for ages, exposed to the weather, the calcareous part of it is dissolved, and the siliceous part is left in form of a soft white earth. But whether this dissolution is performed by pure water, or by means also of an acid, may perhaps be questioned. This, however, is certain, that we must consider siliceous substances as insoluble in water.

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THE water of Giezer in Iceland undoubtedly contains this substance in solution ; but there is no reason to believe, that it is here dissolved by any other than the natural means ; that is, an alkaline substance, by which siliceous bodies may be rendered soluble in water.

It may be, therefore, asserted, that no siliceous body having the hardness of flint, nor any crystallization of that substance, has ever been formed, except by fusion. If, by any art, this substance shall be dissolved in simple water, or made to crystallize from any solution, in that case, the assertion which has been here made may be denied. But where there is not the vestige of any proof, to authorise the supposition of flinty matter being dissolved by water, or crystallized from that solution, such an hypothesis cannot be admitted, in opposition to general and evident appearances.

BESIDES this proof for the fusion of siliceous bodies, which is indirect, arising from the indissolubility of that substance in water, there is another, which is more direct, being founded upon appearances which are plainly inconsistent with any other supposition, except that of simple fluidity induced by heat. The proof I mean is, the penetration of many bodies with a flinty substance, which, according to every collateral circumstance, must have been performed by the flinty matter in a simply fluid state, and not in a state of dissolution by a solvent.

THESE are flinty bodies perfectly insulated in strata both of chalk and sand. It requires but inspection to be convinced. It is not possible that flinty matter could be conveyed into the middle of those strata, by a menstruum in which it was dissolved, and thus deposited in that place, without the smallest trace of deposition in the surrounding parts.

BUT, besides this argument taken from what does not appear, the actual form in which those flinty masses are found, demonstrates,

strates, *first*, That they have been introduced among those strata in a fluid state, by injection from some other place. *2dly*, That they have been dispersed in a variety of ways among those strata, then deeply immersed at the bottom of the sea; and, *lastly*, That they have been there congealed from the state of fusion, and have remained in that situation, while those strata have been removed from the bottom of the ocean to the surface of the present land.

To describe those particular appearances would draw this paper beyond the bounds of an essay. We must, therefore, refer those who would enquire more minutely into the subject, to examine the chalk-countries of France and England, in which the flint is found variously formed; the sand-hills interspersed among those chalk-countries, which have been also injected by melted flint; and the pudding-stone of England, which I have not seen in its natural situation. More particularly, I would recommend an examination of the insulated masses of stone, found in the sand-hills by the city of Brussels; a stone which is formed by an injection of flint among sand, similar to that which, in a body of gravel, had formed the pudding-stone of England*.

ALL these examples would require to be examined upon the spot, as a great part of the proof for the fusion of the flinty substance, arises, in my opinion, from the form in which those bodies are found, and the state of the surrounding parts. But there are specimens brought from many different places, which contain, in themselves, the most evident marks of this injection of the flinty substance in a fluid state. These are pieces of fossil wood, penetrated with a siliceous substance, which are brought from England, Germany, and Lochneagh in Ireland.

It appears from these specimens, that there has sometimes been a prior penetration of the body of wood, either with

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irony matter, or calcareous substance. Sometimes, again, which is the case with that of Lochneagh, there does not seem to have been any penetration of those two substances. The injected flint appears to have penetrated the body of this wood, immersed at the bottom of the sea, under an immense compression of water. This appears from the wood being penetrated partially, some parts not being penetrated at all.

Now, in the limits between those two parts, we have the most convincing proofs, that it had been flint in a simple fluid state which had penetrated the wood, and not in a state of solution.

First, BECAUSE, however little of the wood is left unpenetrated, the division is always distinct between the injected part and that which is not penetrated by the fluid flint. In this case, the flinty matter has proceeded a certain length, which is marked, and no farther; and, beyond this boundary, there is no partial impregnation, nor a gradation of the flintifying operation, as must have been the case if siliceous matter had been deposited from a solution. *2dly*, The termination of the flinty impregnation has assumed such a form, precisely, as would naturally happen from a fluid flint penetrating that body.

IN other specimens of this mineralizing operation, fossil wood, penetrated, more or less, with ferruginous and calcareous substances, has been afterwards penetrated with a flinty substance. In this case, with whatever different substances the woody body shall be supposed to have been penetrated in a state of solution by water, the regular structure of the plant would still have remained, with its vacuities variously filled with the petrifying substances, separated from the aqueous menstruum, and deposited in the vascular structure of the wood.

THERE cannot be a doubt with regard to the truth of this proposition; for as it is, we frequently find parts of the consolidated wood, with the vascular structure remaining perfectly
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in its natural shape and situation ; but if it had been by aqueous solution that the wood had been penetrated and consolidated, all the parts of that body would be found in the same natural shape and situation.

THIS, however, is far from being the case ; for while, in some parts, the vascular structure is preserved entire, it is also evident, that, in general, the woody structure is variously broken and dissolved by the fusion and crystallization of the flint. There are so many and such various convincing examples of this, that, to attempt to describe them, would be to exceed the bounds prescribed for this dissertation ; but such specimens are in my possession, ready for the inspection of any person who may desire to study the subject.

WE may now proceed to consider sulphureous substances, with regard to their solubility in water, and to the part which these bodies have acted in consolidating the strata of the globe.

THE sulphureous substances here meant to be considered, are substances not soluble in water, so far as we know, but fusible by heat, and inflammable by means of heat and vital air. These substances are of two kinds ; the one more simple, the other more compound.

THE most simple kind is composed of two different substances, *viz.* phlogiston, with acid or metallic substances ; from which result, on the one hand, sulphur, and, on the other, metals, both properly so called. The more compound sort, again, is oily matter, produced by vegetables, and forming bituminous bodies.

THE *first* of these is found naturally combined with almost all metallic substances, which are then said to be mineralized with sulphur. Now, it is well known, that this mineralizing operation is performed by means of heat or fusion ; and there is no person skilled in chemistry that will pretend to say, this may be done by aqueous solution. The combination of iron and sulphur, for example, may easily be performed by fusion ;

but, by aqueous solution, this particular combination is again resolved, and forms an acido-metallic, that is, a vitriolic substance, after the phlogiston (which refuses aqueous solution) has been separated from the composition, by means of the joint operation of vital air.

THE variety of these sulphureo-metallic substances, in point of composition, is almost indefinite; but, unless they were all soluble in water, this could not have happened by the action of that solvent. If we shall allow any one of those bodies to have been formed by the fluidity of heat, they must all have been formed in the same manner; for there is such a chain of connection among those bodies in the mineral regions, that they must all have been composed, either, on the one hand, by aqueous solution, or, on the other, by means of heat and fusion.

HERE, for example, are crystallized together in one mass, *first*, *Pyrites*, containing sulphur, iron, copper; *2dly*, *Blend*, a composition of iron, sulphur, and calamine; *3dly*, *Galena*, consisting of lead and sulphur; *4thly*, *Marmor metallicum*, being the terra ponderosa, saturated with the vitriolic acid; a substance insoluble in water; *5thly*, *Fluor*, a saturation of calcareous earth, with a peculiar acid, called the acid of spar, also insoluble in water; *6thly*, *Calcareous spar*, of different kinds, being calcareous earth saturated with fixed air, and something besides, which forms a variety in this substance; *lastly*, *Siliceous substance*, or *Quartz crystals*. All these bodies, each possessing its proper shape, are mixed in such a manner as it would be endless to describe, but which may be expressed in general by saying, that they are mutually contained in, and contain each other.

UNLESS, therefore, every one of these different substances may be dissolved in water, and crystallized from it, it is in vain to look for the explanation of these appearances in the operations of nature, by the means of aqueous solution.

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ON the other hand, heat being capable of rendering all these substances fluid, they may be, with the greatest simplicity, transported from one place to another; and they may be made to concrete altogether, at the same time, and distinctly separate in any place. Hence, for the explanation of those natural appearances, which are so general, no further conditions are required, than the supposition of a sufficient intensity of subterraneous fire or heat, and a sufficient degree of compression upon those bodies, which are to be subjected to that violent heat, without calcination or change. But, so far as this supposition is not gratuitous, the appearances of nature will be thus explained.

I SHALL only mention one specimen, which must appear most decisive of the question. It is, I believe, from an Hungarian mine. In this specimen, petro-felix, pyrites, and cinnabar, are so mixed together, and crystallized upon each other, that it is impossible to conceive any one of those bodies to have had its fluidity and concretion from a cause which had not affected the other two. Now, let those who would deny the fusion of this siliceous body explain how water could dissolve these three different bodies, and deposit them in their present shape. If, on the contrary, they have not the least shadow of reason for such a gratuitous supposition, the present argument must be admitted in its full force.

SULPHUR and metals are commonly found combined in the mineral regions. But this rule is not universal; for they are also frequently in a separate state. There is not, perhaps, a metal, among the great number which are now discovered, that may not be found native, as they are called, or in their metallic state.

METALLIC substances are also thus found in some proportion to the disposition of the particular metals, to resist the mineralizing operations, and to their facility of being metallized by fire and fusion. Gold, which refuses to be mineralized with
fulphur,

fulphur, is found generally in its native state. Iron, again, which is so easily mineralized and scorified, is seldom found in its malleable state. The other metals are all found more or less mineralized, though some of them but rarely in the native state.

BESIDES being found with circumstances thus corresponding to the natural facility, or to the impediments attending the metallization of those different calces, the native metals are also found in such a shape, and with such marks, as can only agree with the fusion of those bodies; that is to say, those appearances are perfectly irreconcilable with any manner of solution and precipitation.

FOR the truth of this assertion, among a thousand other examples, I appeal to that famous mass of native iron, discovered, by Mr PALLAS, in Siberia. This mass being so well known to all the mineralists of Europe, any comment upon its shape and structure will be unnecessary*.

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* SINCE this Dissertation was written, M. DE LA PEYROUSE has discovered a native manganese. The circumstances of this mineral are so well adapted for illustrating the present doctrine, and so well related by M. DE LA PEYROUSE, that I should be wanting to the interest of mineral knowledge, were I not to give here that part of his Memoir.

“ LORSQUE je fis insérer dans le journal de physique de l'année 1780, au mois de Janvier, une Dissertation contenant la classification des mines de manganèse, je ne connoissois point, à cette époque, la mine de manganèse native. Elle a la couleur de son régule: elle salit les doigts de la même teinte. Son tissu paroît aussi lamelleux, et les lames semblent affecter une sorte de divergence. Elle a ainsi que lui, l'éclat métallique; comme lui elle se laisse aplatis sous le marteau, et s'exfolie si l'on redouble les coups; mais une circonstance qui est trop frappante pour que je l'omette, c'est la figure de la manganèse native, si prodigieusement conforme à celle du régule, qu'on s'y laisseroit tromper, si la mine n'étoit encore dans sa gangue: figure très-essentielle à observer ici, parce qu'elle est due à la nature même de la manganèse. En effet, pour réduire toutes les mines en général, il faut employer divers flux appropriés. Pour la réduction de la manganèse, bien loin d'user de ce moyen, il faut, au contraire, éloigner tout flux, produire la fusion, par la seule violence et la promptitude du feu. Et telle est la propension naturelle et prodigieuse de la manganèse à la vitrification, qu'on n'a pu parvenir encore à réduire son régule en un seul culot; on trouve dans le creuset plusieurs petits boutons, qui forment autant de culots

WE come now to the *second* species of inflammable bodies called oily or bituminous. These substances are also found variously mixed with mineral bodies, as well as forming strata of themselves; they are, therefore, a proper subject for a particular examination.

IN the process of vegetation, there are produced oily and resinous substances; and from the collection of these substances at the bottom of the ocean, there are formed strata, which have afterwards undergone various degrees of heat, and have been variously changed, in consequence of the effects of that heat, according as the distillation of the more volatile parts of those bodies has been suffered to proceed.

IN order to understand this, it must be considered, that, while immersed in water, and under insuperable compression, the vegetable, oily, and resinous substances, would appear to be unalterable by heat; and it is only in proportion as certain chemical separations take place, that these inflammable bodies are changed in their substance by the application of heat. Now, the most general change of this kind is in consequence of evaporation, or the distillation of their more volatile parts, by which oily substances become bituminous, and bituminous substances become coaly.

THERE is here a gradation which may be best understood by comparing the extremes.

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lots séparés. Dans la mine de manganèse native, elle n'est point en une seule masse; elle est disposée également en plusieurs culots séparés, et un peu aplatis, comme ceux que l'art produit; beaucoup plus gros, à la vérité, parce que les agens de la nature doivent avoir une autre énergie, que ceux de nos laboratoires; et cette ressemblance si exacte, semble devoir vous faire penser que la mine native a été produite par le feu, tout comme son régule. La présence de la chaux argentée de la manganèse, me permettroit de croire que la nature n'a fait que réduire cette chaux. Du reste, cette mine native est très-pure, et ne contient aucune partie attirable à l'aimant. Cette mine, unique jusqu'à ce moment, vient, tout comme les autres manganèse que j'ai décrites, des mines de fer de Sem, dans la vallée de Viedersos, en Comté de Foix." *Journal de Physique*, Janvier 1786.

ON the one hand, we know by experiment, that oily and bituminous substances can be melted and partly changed into vapour by heat, and that they become harder and denser, in proportion as the more volatile parts have evaporated from them. On the other hand, coaly substances are destitute of fusibility and volatility, in proportion as they have been exposed to greater degrees of heat, and to other circumstances favourable to the dissipation of their more volatile and fluid parts.

IF, therefore, in mineral bodies, we find the two extreme states of this combustible substance, and also the intermediate states, we must either conclude, that this particular operation of heat has been thus actually employed in nature, or we must explain those appearances by some other means, in as satisfactory a manner, and so as shall be consistent with other appearances.

IN this case, it will avail nothing to have recourse to the false analogy of water dissolving and crystallizing salts, which has been so much employed for the explanation of other mineral appearances. The operation here in question is of a different nature, and necessarily requires both the powers of heat and proper conditions for evaporation.

THEREFORE, in order to decide the point, with regard to what is the power in nature by which mineral bodies have become solid, we have but to find bituminous substance in the most complete state of coal, intimately connected with some other substance, which is more generally found consolidating the strata, and assisting in the concretion of mineral substances. But I have in my possession the most undoubted proof of this kind. It is a mineral vein, or cavity, in which are blended together coal of the most fixed kind, quartz and marmor metallicum. Nor is this all; for the specimen now referred to is contained in a rock of this kind, which every naturalist now-a-days will allow to have congealed from a fluid state of fusion. I have also similar specimens from the same place, in which the coal

coal is not of that fixed and infusible kind, which burns without flame or smoak, but is bituminous or inflammable coal.

WE have hitherto been resting the argument upon a single point, for the sake of simplicity or clearness, not for want of those circumstances which shall be found to corroborate the theory. The strata of fossil coal are found in almost every intermediate state, as well as in those of bitumen and charcoal. Of the one kind is that fossil coal which melts or becomes fluid upon receiving heat; of the other, is that species of coal, found both in Wales and Scotland, which is perfectly infusible in the fire, and burns like coaks, without flame or smoak. The one species abounds in oily matter, the other has been distilled by heat, until it has become a *caput mortuum*, or perfect coal.

THE more volatile parts of these bituminous bodies are found in their separate state on some occasions. There is a stratum of limestone in Fifeshire near Raith, which, though but slightly tinged with a black colour, contains bituminous matter, like pitch, in many cavities, which are lined with calcareous spar crystallized. I have a specimen of such a cavity, in which the bitumen is in sphericles, or rounded drops, immersed in the calcareous spar.

Now, it is to be observed, that, if the cavity in the solid limestone or marble, which is lined with calcareous crystals containing pyrites, had been thus encrusted by means of the filtration of water, this water must have dissolved calcareous spar, pyrites and bitumen. But these natural appearances would not even be explained by this dissolution and supposed filtration of those substances. There is also required, *first*, a cause for the separation of those different substances from the aqueous menstruum in which they had been dissolved: *2dly*, An explanation of the way in which a dissolved bitumen should be formed into round hard bodies of the most solid structure; and, *lastly*, Some probable means for this complicated operation being performed,

formed, below the bottom of the ocean, in the close cavity of a marble stratum.

THUS, the additional proof, from the facts relating to the bituminous substances, conspiring with that from the phænomena of other bodies, affords the strongest corroboration of this opinion, that the various concretions found in the internal parts of strata have not been occasioned by means of aqueous solution, but by the power of heat and operation of simple fusion, preparing those different substances to concrete and crystallize in cooling.

THE arguments which have been now employed for proving that strata have been consolidated by the power of heat, or by the means of fusion, have been drawn chiefly from the insoluble nature of those consolidating substances in relation to water, which is the only general menstruum that can be allowed for the mineral regions. But there are found in the mineral kingdom, many solid masses of sal gem, which is a soluble substance. It may be now enquired, How far these masses, which are not unfrequent in the earth, tend either to confirm the present theory, or, on the contrary, to give countenance to that which supposes water the chief instrument in consolidating strata.

THE formation of salt at the bottom of the sea, without the assistance of subterranean fire, is not a thing un-supposable, as at first sight it might appear. Let us but suppose a rock placed across the gut of Gibraltar, (a case nowise unnatural), and the bottom of the Mediterranean would be certainly filled with salt, because the evaporation from the surface of that sea exceeds the measure of its supply.

BUT strata of salt, formed in this manner at the bottom of the sea, are as far from being consolidated by means of aqueous solution, as a bed of sand in the same situation; and we cannot explain the consolidation of such a stratum of salt by means of water, without supposing subterranean heat employed,
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to evaporate the brine which would successively occupy the interstices of the saline crystals. But this, it may be observed, is equally departing from the natural operation of water, as the means for consolidating the sediment of the ocean, as if we were to suppose the same thing done by heat and fusion. For the question is not, If subterranean heat be of sufficient intensity for the purpose of consolidating strata by the fusion of their substances; the question is, Whether it be by means of this agent, subterranean heat, or by water alone, without the operation of a melting heat, that those materials have been variously consolidated.

THE example now under consideration, consolidated mineral salt, will serve to throw some light upon the subject; for as it is to be shewn, that this body of salt had been consolidated by perfect fusion, and not by means of aqueous solution, the consolidation of strata of indissoluble substances, by the operation of a melting heat, will meet with all that confirmation which the consistency of natural appearances can give.

THE salt rock in Cheshire lies in strata of red marl. It is horizontal in its direction. I do not know its thickness, but it is dug thirty or forty feet deep. The body of this rock is perfectly solid, and the salt, in many places, pure, colourless and transparent, breaking with a sparry cubical structure. But the greatest part is tinged by the admixture of the marl, and that in various degrees, from the slightest tinge of red, to the most perfect opacity. Thus, the rock appears as if it had been a mass of fluid salt, in which had been floating a quantity of marly substance, not uniformly mixed, but every where separating and subsiding from the pure saline substance.

THERE is also to be observed a certain regularity in this separation of the tinging from the colourless substance, which, at a proper distance, gives to the perpendicular section of the rock a distinguishable figure in its structure. When looking at this appearance near the bottom of the rock, it, at first, pre-

presented me with the figure of regular stratification; but, upon examining the whole mass of rock, I found, that it was only towards the bottom that this stratified appearance took place; and that, at the top of the rock, the most beautiful and regular figure was to be observed; but a figure the most opposite to that of stratification. It was all composed of concentric circles; and these appeared to be the section of a mass, composed altogether of concentric spheres, like those beautiful systems of configuration which agates so frequently present us with in miniature. In about eight or ten feet from the top, the circles growing large, were blended together, and gradually lost their regular appearance, until, at a greater depth, they again appeared in resemblance of a stratification.

THIS regular arrangement of the floating marly substance in the body of salt, which is that of the structure of a coated pebble, or that of concentric spheres, is altogether inexplicable upon any other supposition, than the perfect fluidity or fusion of the salt, and the attractions and repulsions of the contained substances. It is in vain to look, in the operations of solution and evaporation, for that which nothing but perfect fluidity or fusion can explain.

THIS example of a mineral salt congealed from a melted state, may be confirmed from another which I have from Dr BLACK, who suggested it to me. It is an alkaline salt, found in a mineral state, and described in the Philosophical Transactions, *anno* 1771. But to understand this specimen, something must be premised with regard to the nature of fossil alkali.

THE fossil alkali crystallizes from a dissolved state, in combining itself with a large portion of the water, in the manner of alum; and, in this case, the water is essential to the constitution of that transparent crystalline body; for, upon the evaporation of the water, the transparent salt loses its solidity, and becomes a white powder. If, instead of being gently dried, the

the crystalline salt is suddenly exposed to a sufficient degree of heat, that is, somewhat more than boiling water, it enters into the state of aqueous fusion, and it boils, in emitting the water by means of which it had been crystallized in the cold, and rendered fluid in that heated state. It is not possible to crystallize this alkaline salt from a dissolved state, without the combination of that quantity of water, nor to separate that water without destroying its crystalline state.

BUT in this mineral specimen, we have a solid crystalline salt, with a structure which, upon fracture, appears to be sparry and radiated, something resembling that of zeolite. It contains no water in its crystallization, but melts in a sufficient heat, without any aqueous fusion. Therefore, this salt must have been in a fluid state of fusion, immediately before its congelation and crystallization.

IT would be endless to give examples of particular facts, so many are the different natural appearances that occur, attended with a variety of different circumstances.

THERE is one, however, which is peculiarly distinct, admits of sufficiently accurate description, and contains circumstances from which conclusions may be drawn with clearness. This is the iron-stone, which is commonly found among the argillaceous strata, attendant upon fossil coal, both in Scotland and in England.

THIS stone is generally found among the bituminous schistus, or black argillaceous strata, either in separate masses of various shapes and sizes, or forming of itself strata which are more or less continuous in their direction among the schistus or argillaceous beds.

THIS mineral contains in general from 40 to 50 *per cent.* of iron, and it loses near one third of its weight in calcination. Before calcination it is of a gray colour, is not penetrable by water, and takes a polish. In this state, therefore, it is perfectly solid; but being calcined, it becomes red, porous, and tender.

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THE fact to be proved with regard to these iron-stones is this, That they have acquired their solid state from fusion, and not in concreting from any aqueous solution.

To abridge this disquisition, no argument is to be taken from contingent circumstances, (which, however, are often found here as well as in the case of marbles); such only are to be employed as are general to the subject, and arise necessarily from the nature of the operation.

It will be proper to describe a species of these stones, which is remarkably regular in its form. It is that found at Aberlady in East Lothian.

THE form of these iron-stones is that of an oblate or much compressed sphere, and the size from two or three inches diameter to more than a foot. In the circular or horizontal section, they present the most elegant septarium*; and, from the examination of this particular structure, the following conclusions may be drawn.

First, THAT the septa have been formed by the uniform contraction of the internal parts of the stone, the volume of the central parts diminishing more than that of the circumference; by this means, the separations of the stone diminish, in a progression from the centre towards the circumference.

2d, THAT there are only two ways in which the septa must have received the spar with which they are filled, more or less, either, *first*, By insinuation into the cavity of the septa after these were formed; or, *2dly*, By separation from the substance of the stone, at the same time that the septa were forming.

WERE the first supposition true, appearances would be observable, shewing that the sparry substance had been admitted, either through the porous structure of the stone, or through proper apertures communicating from without. Now, if either one or other of these had been the case, and that the stone had been consolidated from no other cause than concretion from a dissolved

* Plate I.

dissolved state, that particular structure of the stone, by means of which the spar had been admitted, must appear at present upon an accurate examination.

THIS, however, is not the case, and we may rest the argument here. The septa reach not the circumference; the surface of the stone is solid and uniform in every part; and there is not any appearance of the spar in the argillaceous bed around the stone.

It, therefore, necessarily follows, that the contraction of the iron-stone, in order to form septa, and the filling of these cavities with spar, had proceeded *pari passu*; and that this operation must have been brought about by means of fusion, or by congelation from a state of simple fluidity and expansion.

It is only further to be observed, that all the arguments which have been already employed, concerning mineral concretions from a simply fluid state, or that of fusion, here take place. I have septaria of this kind, in which, besides pyrites, iron-ore, calcareous spar, and another that is ferruginous and compound, there is contained siliceous crystals; a case which is not so common. I have them also attended with circumstances of concretion and crystallization, which, besides being extremely rare, are equally curious and interesting.

THERE is one fact more which is well worth our attention, being one of those which are so general in the mineral regions. It is the crystallizations which are found in close cavities of the most solid bodies.

NOTHING is more common than this appearance. Cavities are every where found closely lined with crystallizations, of every different substance which may be supposed in those places. These concretions are well known to naturalists, and form part of the beautiful specimens which are preserved in the cabinets of collectors, and which the German mineralists have termed *Drusen*. I shall only particularize one species, which may be described upon principle, and therefore may be a proper

per subject on which to reason, for ascertaining the order of production in certain bodies. This body, which we are now to examine, is of the agate species.

WE have now been considering the means employed by nature in consolidating strata which were originally of an open structure; but in perfectly solid strata, we find bodies of agate, which have evidently been formed in that place where they now are found. This fact, however, is not still that of which we are now particularly to enquire; for this, of which we are to treat, concerns only a cavity within this agate; now, whatever may have been the origin of the agate itself, we are to shew, from what appears within its cavity, that the crystallizations which are found in this place had arisen from a simply fluid state, and not from that of any manner of solution.

THE agates now in question are those of the coated kind, so frequent in this country, called pebbles. Many of these are filled with a siliceous crystallization, which evidently proceeds from the circumference towards the centre. Many of them, again, are hollow. Those cavities are variously lined with crystallized substances; and these are the object of the present examination.

BUT before describing what is found within, it is necessary to attend to this particular circumstance, that the cavity is perfectly inclosed with many solid coats, impervious to air or water, but particularly with the external cortical part, which is extremely hard, takes the highest polish, and is of the most perfect solidity, admitting the passage of nothing but light and heat.

WITHIN these cavities, we find, *first*, The coat of crystals with which this cavity is always lined; and this is general to all substances concreting, in similar circumstances, from a state of fusion; for when thus at liberty they naturally crystallize. *2dly*, We have frequently a subsequent crystallization, set upon the first, and more or less immersed in it. *3dly*, There is also sometimes

sometimes a third crystallization, superincumbent on the second, in like manner as the second was on the first. I shall mention some particulars.

I HAVE one specimen, in which the primary crystals are filiceous, the secondary thin foliaceous crystals of deep red but transparent iron-ore, forming elegant figures, that have the form of roses. The tertiary crystallization is a frosting of small filiceous crystals upon the edges of the foliaceous crystals.

IN other specimens, there is first a lining of colourless filiceous crystals, then another lining of amethystine crystals, and sometimes within that, fuliginous crystals. Upon these fuliginous and amethystine crystals are many sphericles or hemispheres of red compact iron-ore, like hæmatites.

IN others, again, the primary crystals are filiceous, and the secondary calcareous. Of this kind, I have one which has, upon the calcareous crystals, beautiful transparent filiceous crystals, and iron-sphericles upon these.

Lastly, I HAVE an agate formed of various red and white coats, and beautifully figured. The cavity within the coated part of the pebble is filled up without vacuity, first, with colourless filiceous crystals; secondly, with fuliginous crystals; and, lastly, with white or colourless calcareous spar. But between the spar and crystals there are many sphericles, seemingly of iron, half sunk into each of these two different substances.

FROM these facts, I may now be allowed to draw the following conclusions:

First, THAT concretion had proceeded from the surface of the agate body inwards. This necessarily follows from the nature of those figured bodies, the figures of the external coats always determining the shape of those within, and never, contrarily, those within affecting those without.

2dly, THAT when the agate was formed, the cavity then contained every thing which now is found within it, and nothing more.

3dly, THAT the contained substances must have been in a fluid state, in order to their crystallizing.

Lastly, THAT as this fluid state had not been the effect of solution in a menstruum, it must have been fluidity from heat and fusion.

THERE are in jaspers and agates many other appearances, from whence this last conclusion may be formed with great certainty and precision; but it is hoped, that what has been now given may suffice for establishing that proposition without any doubt.

It must not be here objected, That there are frequently found siliceous crystals and amethysts containing water; and that it is impossible to confine water even in melted glass. It is true, that here, at the surface of the earth, melted glass cannot, in ordinary circumstances, be made to receive and inclose condensed water; but let us only suppose a sufficient degree of compression in the body of melted glass, and we can easily imagine it to receive and confine water, as well as any other substance. But if, even in our operations, water, by means of compression, may be made to endure the heat of red hot iron without being converted into vapour, what may not the power of nature be able to perform? The place of mineral operations is not on the surface of the earth; and we are not to limit nature with our imbecility, or estimate the powers of nature by the measure of our own.

To conclude this long chemico-mineral disquisition, I have specimens in which the mixture of calcareous, siliceous and metallic substances, in almost every species of concretion which is to be found in mineral bodies, may be observed, and in which there is exhibited, in miniature, almost every species of mineral transaction, which, in nature, is found upon a scale of grandeur and magnificence. They are nodules contained in the whinstone, porphyry, or basalt of the Calton-hill, by Edinburgh; a body which is to be afterwards examined, when
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it will be found to have flowed, and to have been in fusion, by the operation of subterraneous heat.

THIS evidence, though most conclusive with regard to the application of subterraneous heat, as the means employed in bringing into fusion all the different substances with which strata may be found consolidated, is not directly a proof that strata had been consolidated by the fusion of their proper substance. It was necessary to see the general nature of the evidence, for the universal application of subterraneous heat, in the fusion of every kind of mineral body. Now, that this has been done, we may give examples of strata consolidated without the introduction of foreign matter, merely by the softening or fusion of their own materials.

FOR this purpose, we may consider two different species of strata, such as are perfectly simple in their nature, of the most distinct substances, and whose origin is perfectly understood, consequently, whose subsequent changes may be reasoned upon with certainty and clearness. These are the siliceous and calcareous strata; and these are the two prevailing substances of the globe, all the rest being, in comparison of these, as nothing; for unless it be the bituminous or coal strata, there is hardly any other which does not necessarily contain more or less of one or other of these two substances. If, therefore, it can be shewn, that both of those two general strata have been consolidated by the simple fusion of their substance, no *desideratum* or doubt will remain, with regard to the nature of that operation which has been transacted at great depths of the earth, places to which all access is denied to mortal eyes.

WE are now to prove, *first*, That those strata have been consolidated by simple fusion; and, *2dly*, That this operation is universal, in relation to the strata of the earth, as having produced the various degrees of solidity or hardness in these bodies.

I SHALL first remark, that a fortuitous collection of hard bodies, such as gravel and sand, can only touch in points, and

cannot, while in that hard state, be made to correspond so precisely to each other's shape as to consolidate the mass. But if these hard bodies should be softened in their substance, or brought into a certain degree of fusion, they might be adapted mutually to each other, and thus consolidate the open structure of the mass. Therefore, to prove the present point, we have but to exhibit specimens of siliceous and calcareous strata which have been evidently consolidated in this manner.

Of the first kind, great varieties occur in this country. It is, therefore, needless to describe these particularly. They are the consolidated strata of gravel and sand, often containing abundance of feld-spar, and thus graduating into granite; a body, in this respect, perfectly similar to the more regular strata which we now examine.

THE second kind, again, are not so common in this country, unless we consider the shells and coralline bodies in our limestones, as exhibiting the same example, which indeed they do. But I have a specimen of marble from Spain, which may be described, and which will afford the most satisfactory evidence of the fact in question.

THIS Spanish marble may be considered as a species of pudding-stone, being formed of calcareous gravel; a species of marble which, from Mr BOWLES's Natural History, appears to be very common in Spain. The gravel of which this marble is composed, consists of fragments of other marbles of different kinds. Among these, are different species of *oolites* marble, some shell marbles, and some composed of a chalky substance, or of undistinguishable parts. But it appears, that all these different marbles had been consolidated or made hard, then broken into fragments, rolled and worn by attrition, and thus collected together, along with some sand or small siliceous bodies, into one mass. *Lastly*, This compound body is consolidated in such a manner as to give the most distinct evidence, that

that this had been executed by the operation of heat or simple fusion.

THE proof I give is this, That besides the general conformation of those hard bodies, so as to be perfectly adapted to each other's shape, there is, in some places, a mutual indentation of the different pieces of gravel into each other; an indentation which resembles perfectly that junction of the different bones of the *cranium*, called futures, and which must have necessarily required a mixture of those bodies while in a soft or fluid state.

THIS appearance of indentation is, by no means, singular or limited to one particular specimen. I have several specimens of different marbles, in which fine examples of this species of mixture may be perceived. But in this particular case of the Spanish pudding-stone, where the mutual indentation is made between two pieces of hard stone, worn round by attrition, the softening or fusion of these two bodies is not simply rendered probable, but demonstrated.

HAVING thus proved, that those strata had been consolidated by simple fusion, as proposed, we now proceed to shew, that this mineral operation had been not only general, as being found in all the regions of the globe, but universal, in consolidating our earth in all the various degrees, from loose and incoherent shells and sand, to the most solid bodies of the siliceous and calcareous substances.

To exemplify this in the various collections and mixtures of sands, gravels, shells and corals, were endless and superfluous. I shall only take, for an example, one simple homogeneous body, in order to exhibit it in the various degrees of consolidation, from the state of simple incoherent earth to that of the most solid marble. It must be evident that this is chalk; naturally a soft calcareous earth, but which may be also found consolidated in every different degree.

THROUGH the middle of the isle of Wight, there runs a ridge of hills of indurated chalk. This ridge runs from the
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isle of Wight directly west into Dorsetshire, and goes by Corfe castle towards Dorchester, perhaps beyond that place. The sea has broke through this ridge at the west end of the isle of Wight, where columns of the indurated chalk remain, called the needles; the same appearance being found upon the opposite shore in Dorsetshire.

IN this field of chalk, we find every gradation of that soft earthy substance to the most consolidated body of this indurated ridge, which is not solid marble, but which has lost its chalky property, and has acquired a kind of stony hardness.

WE want only further to see this cretaceous substance in its most indurated and consolidated state; and this we have in the north of Ireland, not far from the Giants Causeway. I have examined cargoes of this limestone brought to the west of Scotland, and find the most perfect evidence of this body having been once a mass of chalk, which is now a solid marble.

THUS, if it is by means of fusion that the strata of the earth have been, in many places, consolidated, we must conclude, that all the degrees of consolidation, which are indefinite, have been brought about by the same means.

Now, that all the strata of the mineral regions, which are those only now examined, have been consolidated in some degree, is a fact for which no proof can be offered here, but must be submitted to experience and enquiry; so far, however, as they shall be considered as consolidated in any degree, which they certainly are in general, we have investigated the means which had been employed in that mineral operation.

WE have now considered the concretions of particular bodies, and the general consolidation of strata; but it may be alleged, that there is a great part of the solid mass of this earth not properly comprehended among those bodies which have been thus proved to be consolidated by means of fusion. The body here alluded to is granite; a mass which is not generally stratified, and which, being a body perfectly solid, and forming

forming some part in the structure of this earth, deserves to be considered.

THE nature of granite, as a part of the structure of the earth, is too intricate a subject to be here considered, where we only seek to prove the fusion of a substance from the evident marks which are to be observed in a body. We shall, therefore, only now consider one particular species of granite; and if this shall appear to have been in a fluid state of fusion, we may be allowed to extend this property to all the kind.

THE species now to be examined comes from the north country, about four or five miles west from Portsoy, on the road to Huntly. I have not been upon the spot, but am informed that this rock is immediately connected or continuous with the common granite of the country. This indeed appears in the specimens which I have got; for, in some of these, there is to be perceived a gradation from the regular to the irregular sort.

THIS rock may indeed be considered, in some respects, as a porphyry; for it has an evident ground, which is feld-spar, in its sparry state; and it is, in one view, distinctly maculated with quartz, which is transparent, but somewhat dark-coloured*.

CONSIDERED as a porphyry, this specimen is no less singular than as a granite. For, instead of a filiceous ground, maculated with the rhombic feld-spar, which is the common state of porphyry, the ground is uniformly crystallized, or a homogeneous regular feld-spar, maculated with the transparent filiceous substance. But as, besides the feld-spar and quartz, which are the constituent parts of the stone, there is also mica, in some places, it may, with propriety, be termed a granite.

THE singularity of this specimen consists, not in the nature or proportions of its constituent parts, but in the uniformity of the sparry ground, and the regular shape of the quartz mixture. This filiceous substance, viewed in one direction, or longitudinally, may be considered as columnar, prismatical,

or

* Plate II. fig. 1. 2. 3.

or continued in lines running nearly parallel. These columnar bodies of quartz are beautifully impressed with a figure on the sides, where they are in contact with the spar. This figure is that of furrows or channels, which are perfectly parallel, and run across the longitudinal direction of the quartz. This is represented in fig. 4. This striated figure is only seen when, by fracture, the quartz is separated from the contiguous spar.

BUT what I would here more particularly represent is, the transverse section of those longitudinal filiceous bodies. These are seen in fig. 1. 2. and 3. They have not only separately the forms of certain typographic characters, but collectively give the regular lineal appearance of types set in writing.

IT is evident from the inspection of this fossil, that the sparry and filiceous substances had been mixed together in a fluid state; and that the crystallization of the sparry substance, which is rhombic, had determined the regular structure of the quartz, at least in some directions.

THUS, the filiceous substance is to be considered as included in the spar, and as figured according to the laws of crystallization proper to the sparry ground; but the spar is also to be found included in the quartz. It is not, indeed, always perfectly included or inclosed on all sides; but this is sometimes the case, or it appears so in the section. Fig. 5. 6. 7. 8. 9. and 10. are those cases magnified, and represent the different figured quartz inclosing the feld-spar. In one of them, the feld-spar, which is contained within the quartz, contains also a small triangle of quartz, which it incloses. Now, it is not possible to conceive any other way in which those two substances, quartz and feld-spar, could be thus concreted, except by congelation from a fluid state, in which they had been mixed.

THERE is one thing more to be observed with regard to this curious species of granite. It is the different order or arrangement of the crystallization or internal structure of the feld-spar ground, in two contiguous parts of the same mass. This is to be

be perceived in the polished surface of the stone, by means of the reflection of light.

THERE is a certain direction in which, viewing the stone, when the light falls with a proper obliquity, we see a luminous reflection from the internal parts of the stone. This arises from the reflecting surfaces of the sparry structure or minute cracks, all turned in one direction, consequently, giving that luminous appearance only in one point of view.

Now, all the parts of the stone in which the figured quartz is directed in the same manner, or regularly placed in relation to each other, present that shining appearance to the eye at one time, or in the same point of direction. But there are parts of the mass, which, though immediately contiguous and properly continuous, have a different disposition of the figured quartz; and these two distinguished masses, in the same surface of the polished stone, give to the eye their shining appearance in very different directions. Fig. 3. shows two of those figured and shining masses, in the same plane or polished surface.

It must be evident, that, as the crystallization of the sparry structure is the figuring cause of the quartz bodies, there must be observed a certain correspondency between those two things, the alinement (if I may be allowed the expression) of the quartz, and the shining of the sparry ground. It must also appear, that, at the time of congelation of the fluid spar, those two contiguous portions had been differently disposed in the crystallization of their substance. This is an observation which I have had frequent opportunities of making, with respect to masses of calcareous spar.

UPON the whole, therefore, whether we shall consider granite as a stratum or as an irregular mass, whether as a collection of several materials, or as the separation of substances which had been mixed, there is sufficient evidence of this body having been consolidated by means of fusion, and in no other manner.

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WE are thus led to suppose, that the power of heat and operation of fusion must have been employed in consolidating strata of loose materials, which had been collected together and amassed at the bottom of the ocean. It will, therefore, be proper to consider, what are the appearances in consolidated strata that naturally should follow, on the one hand, from fluidity having been, in this manner, introduced by means of heat, and, on the other, from the interstices being filled by means of solution; that so we may compare appearances with the one and other of those two suppositions, in order to know that with which they may be only found consistent.

THE consolidation of strata with every different kind of substance was found to be inconsistent with the supposition, that aqueous solution had been the means employed for this purpose. This appearance, on the contrary, is perfectly consistent with the idea, that the fluidity of these bodies had been the effect of heat; for, whether we suppose the introduction of foreign matter into the porous mass of a stratum for its consolidation, or whether we shall suppose the materials of the mass acquiring a degree of softness, by means of which, together with an immense compression, the porous body might be rendered solid; the power of heat, as the cause of fluidity and vapour, is equally proper and perfectly competent. Here, therefore, appearances are as decidedly in favour of the last supposition, as they had been inconsistent with the first.

BUT if strata have been consolidated by means of aqueous solution, these masses should be found precisely in the same state as when they were originally deposited from the water. The perpendicular section of those masses might shew the compression of the bodies included in them, or of which they are composed; but the horizontal section could not contain any separation of the parts of the stratum from one another.

IF, again, strata have been consolidated by means of heat, acting in such a manner as to soften their substance, then, in cooling,

cooling, they must have formed rents or separations of their substance, by the unequal degrees of contraction which the contiguous strata may have suffered. Here is a most decisive mark by which the present question must be determined.

THERE is not in nature any appearance more distinct than this of the perpendicular fissures and separations in strata. These are generally known to workmen by the terms of veins or backs and cutters; and there is no consolidated stratum that wants these appearances. Here is, therefore, a clear decision of the question, Whether it has been by means of heat, or by means of aqueous solution, that collections of loose bodies at the bottom of the sea have been consolidated into the hardest rocks and most perfect marbles.

ERROR never can be consistent, nor can truth fail of having support from the accurate examination of every circumstance. It is not enough to have found appearances decisive of the question, with regard to the two suppositions which have been now considered, we may farther seek confirmation of that supposition which has been found alone consistent with appearances.

If it be by means of heat and fusion that strata have been consolidated, then, in proportion to the degree of consolidation they have undergone from their original state, they should, *cæteris paribus*, abound more with separations in their mass. But this conclusion is found consistent with appearances. A stratum of porous sand-stone does not abound so much with veins and cutters as a similar stratum of marble, or even a similar stratum of sand-stone that is more consolidated. In proportion, therefore, as strata have been consolidated, they are in general intersected with veins and cutters; and in proportion as strata are deep in their perpendicular section, the veins are wide, and placed at greater distances. In like manner, when strata are thin, the veins are many, but proportionally narrow.

It is thus, upon chemical principles, to be demonstrated, That all the solid strata of the globe have been condensed by

means of heat, and hardened from a state of fusion. But this proposition is equally to be maintained from principles which are mechanical. The strata of the globe, besides being formed of earths, are composed of sand, of gravel, and fragments of hard bodies, all which may be considered as, in their nature, simple; but these strata are also found composed of bodies which are not simple, but are fragments of former strata, which had been consolidated, and afterwards were broken and worn by attrition, so as to be made gravel. Strata composed in this manner have been again consolidated; and now the question is, By what means?

If strata composed of such various bodies had been consolidated, by any manner of concretion, from the fluidity of a dissolution, the hard and solid bodies must be found in their entire state, while the interstices between those constituent parts of the stratum are filled up. No partial fracture can be conceived as introduced into the middle of a solid mass of hard matter, without having been communicated from the surrounding parts. But such partial separations are found in the middle of those hard and solid masses; therefore, this compound body must have been consolidated by other means than that of concretion from a state of a solution.

THE Spanish marble already described, as well as many consolidated strata of siliceous gravel, of which I have specimens, afford the clearest evidence of this fact. These hard bodies are perfectly united together, in forming the most solid mass; the contiguous parts of some of the rounded fragments are interlaced together, as has already been observed; and there are partial shrinkings of the mass forming veins, traversing several fragments, but perfectly filled with the sparry substance of the mass, and sometimes with parts of the stone distinctly floating in the transparent body of spar. Now, there is not, besides heat or fusion, any known power in nature by which these effects might be produced. But such effects are general to all consolidated

consolidated masses, although not always so well illustrated in a cabinet specimen.

THUS we have discovered a truth that is confirmed by every appearance, so far as the nature of the subject now examined admits. We now return to the general operation, of forming continents of those materials which had been deposited at the bottom of the sea.

P A R T III.

Investigation of the Natural Operations employed in the Production of Land above the Surface of the Sea.

WE seek to know that operation by means of which masses of loose materials, collected at the bottom of the sea, were raised above its surface, and transformed into solid land.

WE have found, that there is not in this globe (as a planet revolving in the solar system) any power or motion adapted to the purpose now in view ; nor, were there such a power, could a mass of simply collected materials have continued any considerable time to resist the waves and currents natural to the sea, but must have been quickly carried away, and again deposited at the bottom of the ocean. But we have found, that there had been operations, natural to the bowels of this earth, by which those loose and unconnected materials have been cemented together, and consolidated into masses of great strength and hardness ; those bodies are thus enabled to resist the force of waves and currents, and to preserve themselves, for a sufficient time, in their proper shape and place, as land above the general surface of the ocean.

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WE now desire to know, how far those internal operations of the globe, by which solidity and stability are procured to the beds of loose materials, may have been also employed in raising up a continent of land, to remain above the surface of the sea.

THERE is nothing so proper for the erection of land above the level of the ocean, as an expansive power of sufficient force, applied directly under materials in the bottom of the sea, under a mass that is proper for the formation of land when thus erected. The question is not, how such a power may be procured; such a power has probably been employed. If, therefore, such a power should be consistent with that which we found had actually been employed in preparing the erected mass; or, if such a power is to be reasonably concluded as accompanying those operations which we have found natural to the globe, and situated in the very place where this expansive power appears to be required, we should thus be led to perceive, in the natural operations of the globe, a power as efficacious for the elevation of what had been at the bottom of the sea into the place of land, as it is perfect for the preparation of those materials to serve the purpose of their elevation.

IN opposition to this conclusion, it will not be allowed to allege, that we are ignorant how such a power might be exerted under the bottom of the ocean; for the present question is not, what had been the cause of heat, which has appeared to have been produced in that place; but, if this power of heat, which has certainly been exerted at the bottom of the ocean for consolidating strata, had been employed also for another purpose, that is, for raising those strata into the place of land.

WE may, perhaps, account for the elevation of land, by the same cause with that of the consolidation of strata, already investigated, without explaining the means employed by nature in procuring the power of heat, or shewing from what general source of action this particular power had been derived; but, by finding in subterranean heat a cause for any other change, besides

sides the consolidation of porous or incoherent bodies, we shall generalize a fact, or extend our knowledge in the explanation of natural appearances.

THE power of heat for the expansion of bodies, is, so far as we know, unlimited; but by the expansion of bodies placed under the strata at the bottom of the sea, the elevation of those strata may be affected; and the question now to be resolved regards the actual exertion of this power of expansion, How far it is to be concluded as having been employed in the production of this earth above the level of the sea.

BEFORE attempting to resolve that question, it may be proper to observe, there has been exerted an extreme degree of heat below the strata formed at the bottom of the sea; and this is precisely the action of a power required for the elevation of those heated bodies into a higher place. Therefore, if there is no other way in which we may conceive this event to have been brought about, consistent with the present state of things, or what actually appears, we shall have a right to conclude, that such had been the order of procedure in natural things, and that the strata formed at the bottom of the sea had been elevated, as well as consolidated, by means of subterraneous heat.

THE consolidation of strata by means of fusion or the power of heat, has been concluded from the examination of nature, and from finding, that the present state of things is inconsistent with any other supposition. Now, again, we are considering the only power that may be conceived as capable of elevating strata from the bottom of the sea, and placing such a mass above the surface of the water. It is a truth unquestionable, that what had been originally at the bottom of the sea, is at present the highest of our land. In explaining this appearance, therefore, no other alternative is left, but either to suppose strata elevated by the power of heat above the level of the present sea, or the surface of the ocean reduced many miles below the height

height at which it had subsisted during the collection and induration of the land which we inhabit.

Now, if, on the one hand, we are to suppose no general power of subterraneous fire or heat, we leave to our theory no means for the retreat of the sea, or the lowering of its surface; if, on the other hand, we are to allow the general power of subterraneous heat, we cannot have much difficulty in supposing, either the surface of the sea to have subsided, or the bottom of the ocean, in certain parts, to have been raised by a subterranean power above the level of its surface, according as appearances shall be found to require the one or other of those conclusions. Here, therefore, we are again remitted to the history of nature, in order to find matter of fact by which this question may be properly decided.

If the present land had been discovered by the subsiding of the waters, there has not been a former land, from whence materials had been procured for the construction of the present, when at the bottom of the sea; for there is no vestige remaining of that land, the whole land of the present earth having been formed evidently at the bottom of the sea. Neither could the natural productions of the sea have been accumulated, in the shape in which we now find them, on the surface of this earth; for how should the Alps and Andes have been formed within the sea from the natural productions of the water? Consequently, this is a supposition inconsistent with every natural appearance.

THE supposition, therefore, of the subsidence of the former ocean, for the purpose of discovering the present land, is beset with more difficulty than the simple erection of the bottom of the former ocean; for, *first*, There is a place to provide for the retirement of the waters of the ocean; and, *2dly*, There is required a work of equal magnitude; this is, the swallowing up of that former continent, which had procured the materials of the present land.

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ON the one hand, the subsiding of the surface of the ocean would but make the former land appear the higher; and, on the other, the sinking the body of the former land into the solid globe, so as to swallow up the greater part of the ocean after it, if not a natural impossibility, would be at least a superfluous exertion of the power of nature. Such an operation as this would discover as little wisdom in the end elected, as in the means appropriated to that end; for, if the land be not wasted and worn away in the natural operations of the globe, why make such a convulsion in the world in order to renew the land? If, again, the land naturally decays, why employ so extraordinary a power, in order to hide a former continent of land, and puzzle man?

LET us now consider how far the other proposition, of strata being elevated by the power of heat above the level of the sea, may be confirmed from the examination of natural appearances.

THE strata formed at the bottom of the ocean are necessarily horizontal in their position, or nearly so, and continuous in their horizontal direction or extent. They may change, and gradually assume the nature of each other, so far as concerns the materials of which they are formed; but there cannot be any sudden change, fracture or displacement naturally in the body of a stratum. But, if these strata are cemented by the heat of fusion, and erected with an expansive power acting below, we may expect to find every species of fracture, dislocation and contortion, in those bodies, and every degree of departure from a horizontal towards a vertical position.

THE strata of the globe are actually found in every possible position: For from horizontal, they are frequently found vertical; from continuous, they are broken and separated in every possible direction; and, from a plane, they are bent and doubled. It is impossible that they could have originally been formed, by the known laws of nature, in their present state and position;

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and the power that has been necessarily required for their change, has not been inferior to that which might have been required for their elevation from the place in which they had been formed.

In this case, natural appearances are not anomalous. They are, indeed, infinitely various, as they ought to be, according to the rule; but all those varieties in appearances conspire to prove one general truth, *viz.* That all which we see had been originally composed according to certain principles, established in the constitution of the terraqueous globe; and that those regular compositions had been afterwards greatly changed by the operations of another power, which had introduced apparent confusion among things first formed in order and by rule.

It is concerning the operation of this second power that we are now enquiring; and here the apparent irregularity and disorder of the mineral regions are as instructive, with regard to what had been transacted in a former period of time, as the order and regularity of those same regions are conclusive, in relation to the place in which a former state of things had produced that which, in its changed state, we now perceive.

WE are now to conclude, that the land on which we dwell had been elevated from a lower situation by the same agent which had been employed in consolidating the strata, in giving them stability, and preparing them for the purpose of the living world. This agent is matter actuated by extreme heat, and expanded with amazing force.

If this has been the case, it will be reasonable to expect, that some of the expanded matter might be found condensed in the bodies which have been heated by that igneous vapour; and that matter, foreign to the strata, may have been thus introduced into the fractures and separations of those indurated masses.

WE have but to open our eyes to be convinced of this truth. Look into the sources of our mineral treasures; ask the miner,
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from whence has come the metal into his vein? Not from the earth or air above, not from the strata which the vein traverses; these do not contain one atom of the minerals now considered: There is but one place from whence these minerals may have come; this is, the bowels of the earth, the place of power and expansion, the place from whence must have proceeded that intense heat by which loose materials have been consolidated into rocks, as well as that enormous force by which the regular strata have been broken and displaced.

OUR attention is here peculiarly called upon, where we have the opportunity of examining those mineral bodies, which have immediately proceeded from the unknown region, that place of power and energy which we want to explore; for, if such is the system of the earth, that materials are first deposited at the bottom of the ocean, there to be prepared in a certain manner, in order to acquire solidity, and then to be elevated into the proper place of land, these mineral veins, which contain matter absolutely foreign to the surface of the earth, afford the most authentic information with regard to the operations which we want to understand. It is these veins which we are to consider as, in some measure, the continuation of that mineral region, which lies necessarily out of all possible reach of our examination. It is, therefore, peculiarly interesting to know the state in which things are to be found in this place, which may be considered as intermediate between the solid land, upon the one hand, and the unknown regions of the earth, upon the other.

WE are now to examine those mineral veins; and these may be considered, first, in relation to their form, independent of their substance or particular contents; and, secondly, in relation to the contained bodies, independent of their form.

IN examining consolidated strata, we remarked veins and cutters as a proof of the means by which those bodies had been consolidated. In that case, the formation of these veins is

a regulated process, determined by the degree of fusion, and the circumstances of condensation or refrigeration. In respect of these, the mineral veins now to be examined are anomalous. They are; but we know not why or how. We see the effect; but, in that effect, we do not see the cause. We can say, negatively, that the cause of mineral veins is not that by which the veins and fissures of consolidated strata have been formed; consequently, that it is not the measured contraction and regulated condensation of the consolidated land which has formed those general mineral veins; however, veins, similar in many respects, have been formed by the co-operation of this cause.

HAVING thus taken a view of the evident distinction between the veins or contractions that are particular to the consolidated body in which they are found, and those more general veins which are not limited to that cause, we may now consider what is general in the subject, or what is universal in these effects of which we wish to investigate the cause.

THE event of highest generalization or universality, in the form of those mineral veins, is fracture and dislocation. It is not, like that of the veins of strata, simple separation and measured contraction; it is violent fracture and unlimited dislocation. In the one case, the forming cause is in the body which is separated; for, after the body had been actuated by heat, it is by the reaction of the proper matter of the body, that the chasm which constitutes the vein is formed. In the other case, again, the cause is extrinsic in relation to the body in which the chasm is formed. There has been the most violent fracture and divulsion; but the cause is still to seek; and it appears not in the vein; for it is not every fracture and dislocation of the solid body of our earth, in which minerals, or the proper substances of mineral veins, are found.

WE are now examining matter of fact, real effects, from whence we would investigate the nature of certain events which do not now appear. Of these, two kinds occur; one which has acted

acted in relation to the hardness and solidity, or the natural constitution of the body ; the other, to its shape or local situation. The first has been already considered ; the last is now the subject of enquiry.

BUT, in examining those natural appearances, we find two different kinds of veins ; the one necessarily connected with the consolidating cause ; the other with that cause of which we now particularly enquire. For, in those great mineral veins, violent fracture and dislocation is the principle ; but there is no other principle upon which strata, or masses formed at the bottom of the sea, can be placed at a height above its surface. Hence, in those two different operations, of forming mineral veins, and erecting strata from a lower to a higher place, the principle is the same ; for neither can be done without violent fracture and dislocation.

WE now only want to know, how far it is by the same power, as well as upon the same principle, that those two operations have been made. An expansive force, acting from below, is the power most proper for erecting masses ; but whether it is a power of the same nature with that which has been employed in forming mineral veins, will best appear in knowing the nature of their contents. These, therefore, may be now considered.

EVERY species of fracture, and every degree of dislocation and contortion, may be perceived in the form of mineral veins ; and there is no other general principle to be observed in examining their form. But, in examining their contents, some other principle may appear, so far as, to the dislocating power or force, there may be superadded matter, by which something in relation to the nature of the power may be known. If, for example, a tree or a rock shall be found simply split asunder, although there be no doubt with regard to some power having been applied in order to produce the effect, yet we are left merely to conjecture at the power. But when wedges of wood or
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iron, or frozen water, should be found lodged in the cleft, we might be enabled, from this appearance, to form a certain judgment with regard to the nature of the power which had been applied. This is the case with mineral veins. We find them containing matter, which indicates a cause; and every information in this case is interesting to the theory.

THE substances contained in mineral veins are precisely the same with those which, in the former part of this paper, we have considered as being made instrumental in the consolidation of strata; and they are found in every species of mixture and concretion.

BUT, besides this evidence for the exertion of extreme heat, in that process by which those veins were filled, there is another important observation to be gathered from the inspection of this subject. There appears to have been a great mechanical power employed in the filling of these veins, as well as that necessarily required in making the first fracture and divulsion.

THIS appears from the order of the contents, or filling of these veins, which is a thing often observed to be various and successive. But what it is chiefly now in view to illustrate, is that immense force which is manifested in the fracture and dispersion of the solid contents which had formerly filled those veins. Here we find fragments of rock and spar floating in the body of a vein filled with metallic substances; there, again, we see the various fragments of metallic masses floating in the sparry and filiceous contents.

ONE thing is demonstrable from the inspection of the veins and their contents; this is, the successive irruptions of those fluid substances breaking the solid bodies which they meet, and floating those fragments of the broken bodies in the vein. It is very common to see three successive series of those operations; and all this may be perceived in a small fragment of stone, which a man of science may examine in his closet, often better

better than descending to the mine, where all the examples are found on an enlarged scale.

LET us now consider what power would be required to force up, from the most unfathomable depth of the ocean, to the Andes or the Alps, a column of fluid metal and of stone. This power cannot be much less than that required to elevate the highest land upon the globe. Whether, therefore, we shall consider the general veins as having been filled by mineral steams, or by fluid minerals, an elevating power of immense force is still required, in order to form as well as fill those veins. But such a power acting under the consolidated masses at the bottom of the sea, is the only natural means for making those masses land.

IF such have been the operations that are necessary for the production of this land; and if these operations are natural to the globe of this earth, as being the effect of wisdom in its contrivance, we shall have reason to look for the actual manifestation of this truth in the phenomena of nature, or those appearances which more immediately discover the actual cause in the perceived effect.

To see the evidence of marble, a body that is solid, having been formed of loose materials collected at the bottom of the sea, is not always easy, although it may be made abundantly plain; and to be convinced that this calcareous stone, which calcines so easily in our fires, should have been brought into fusion by subterraneous heat, without suffering calcination, must require a chain of reasoning which every one is not able to attain. But when fire bursts forth from the bottom of the sea, and when the land is heaved up and down, so as to demolish cities in an instant, and split asunder rocks and solid mountains, there is nobody but must see in this a power, which may be sufficient to accomplish every view of nature in erecting land, as it is situated in the place most advantageous for that purpose.

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THE only question, therefore, which it concerns us to decide at present, is, Whether those operations of extreme heat, and violent mechanic force, be only in the system as a matter of accident ; or if, on the contrary, they are operations natural to the globe, and necessary in the production of such land as this which we inhabit. The answer to this is plain : These operations of the globe, remain at present with undiminished activity, or in the fulness of their power.

A stream of melted lava flows from the sides of Mount *Ætna*. Here is a column of weighty matter raised an immense height above the level of the sea, and rocks of an enormous size are projected from its orifice some miles into the air. Every one acknowledges that here is the liquefying power and expansive force of subterranean fire, or violent heat. But that Sicily itself had been raised from the bottom of the ocean, and that the marble called Sicilian Jasper, had its solidity upon the same principle with the lava, would stumble many a naturalist to acknowledge. Nevertheless, I have in my possession a table of this marble, from which it is demonstrable, that this calcareous stone had flowed, and been in such a state of fusion and fluidity as lava.

HERE is a comparison formed of two mineral substances, to which it is of the highest importance to attend. The solidity and present state of the one of these is commonly thought to be the operation of fire ; of the other, again, it is thought to be that of water. This, however, is not the case. The immediate state and condition of both these bodies is now to be considered as equally the effect of fire or heat. The reason of our forming such a different judgment with regard to these two subjects is this ; we see, in the one case, the more immediate connection of the cause and the effect, while, in the other, we have only the effects from whence we are in science to investigate the cause.

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BUT, if it were necessary always to see this immediate connection, in order to acknowledge the operation of a power which, at present, is extinguished in the effect, we should lose the benefit of science, or general principles, from whence particulars may be deduced, and we should be able to reason no better than the brute. Man is made for science; he reasons from effects to causes, and from causes to effects; but he does not always reason without error. In reasoning, therefore, from appearances which are particular, care must be taken how we generalize; we should be cautious not to attribute to nature, laws which may perhaps be only of our own invention.

THE immediate question now before us is not, if the subterraneous fire, or elevating power, which we perceive sometimes as operating with such energy, be the consolidating cause of strata formed at the bottom of the sea; nor, if that power be the means of making land appear above the general surface of the water; for, though this be the end we want to arrive at ultimately, the question at present in agitation respects the laws of nature, or the generality of particular appearances.

HAS the globe within it such an active power as fits it for the renovation of that part of its constitution which may be subject to decay? Are those powerful operations of fire, or subterraneous heat, which so often have filled us with terror and astonishment, to be considered as having always been? Are they to be concluded as proper to every part upon the globe, and as continual in the system of this earth? If these points in question shall be decided in the affirmative, we can be at no loss in ascertaining the power which has consolidated strata, nor in explaining the present situation of those bodies, which had their origin at the bottom of the sea. This, therefore, should be the object of our pursuit; and, in order to have demonstration in a case of physical enquiry, we must again have recourse to the book of nature.

THE general tendency of heat is to produce fluidity and softness ; as that of cold is, on the contrary, to harden soft and fluid bodies. But this softening power of heat is not uniform in its nature ; it is made to act with very different effect, according to the nature of the substance to which it is applied. We are but limited in the art of increasing the heat or the cold of bodies ; we find, however, extreme difference in their substances with respect to fusibility.

A FUSIBLE substance, or mineral composition in a fluid state, is emitted from those places of the earth at which subterraneous fire and expansive force are manifested in those eruptive operations. In examining these emitted bodies, men of science find a character for such productions, in generalizing the substance, and understanding the natural constitution of those bodies. It is in this manner, that such a person, finding a piece of lava in any place of the earth, says with certainty, Here is a stone which had congealed from a melted state.

HAVING thus found a distinguishing character for those fused substances called, in general, lavas, and having the most visible marks for that which had been actually a volcano, naturalists, in examining different countries, have discovered the most undoubted proofs of many ancient volcanos, which had not been before suspected. Thus, volcanos will appear to be not a matter of accident, or as only happening in a particular place, they are general to the globe, so far as there is no place upon the earth that may not have an eruption of this kind ; although it is by no means necessary for every place to have had those eruptions.

VOLCANOS are natural to the globe, as general operations ; but we are not to consider nature as having a burning mountain for an end in her intention, or as a principal purpose in the general system of this world. The end of nature in placing an internal fire or power of heat, and a force of irresistible expansion, in the body of this earth, is to consolidate the sediment collected

collected at the bottom of the sea, and to form thereof a mass of permanent land above the level of the ocean, for the purpose of maintaining plants and animals. The power appointed for this purpose is, as on all other occasions, where the operation is important, and where there is any danger of a shortcoming, wisely provided in abundance; and there are contrived means for disposing of the redundancy. These, in the present case, are our volcanos.

A VOLCANO is not made on purpose to frighten superstitious people into fits of piety and devotion, nor to overwhelm devoted cities with destruction; a volcano should be considered as a spiracle to the subterranean furnace, in order to prevent the unnecessary elevation of land, and fatal effects of earthquakes; and we may rest assured, that they, in general, wisely answer the end of their intention, without being in themselves an end, for which nature had exerted such amazing power and excellent contrivance.

LET us take a view of the most elevated places of the earth; if the present theory is just, it is there that we should find volcanos. But is not this the case? There are volcanos in the Andes; and round the Alps we find many volcanos, which are in France upon the one side, and in Germany upon the other, as well as upon the Italian side, where Vesuvius still continues to exhibit violent eruptions.

It is not meant to allege, that it is only upon the summit of a continent volcanos should appear. Subterraneous fire has sometimes made its appearance in bursting from the bottom of the sea. But, even in this last case, land was raised from the bottom of the sea, before the eruption made its exit into the atmosphere. It must also be evident, that, in this case of the new island near Santorini, had the expansive power been retained, instead of being discharged, much more land might have been raised above the level of the ocean.

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Now, the eruption of that elastic force through the bottom of the sea, may be considered as a waste of power in the operations of the globe, where the elevation of indurated strata is an object in the exertion of that power; whereas, in the centre of a continent sufficiently elevated above the level of the sea, the eruption of that fiery vapour calculated to elevate the land, while it may occasionally destroy the habitations of a few, provides for the security and quiet possession of the many.

IN order to see the wisdom of this contrivance, let us consider the two extreme places at which this eruption of ignited matter may be performed. These are, on the one hand, within a continent of land, and, on the other, at the bottom of the ocean. In the one case, the free eruption of the expanding power should be permitted; because the purpose for which it had been calculated to exist, has been accomplished. In the other, again, the free eruption of that powerful matter should be repressed; because there is reserved for that power much of another operation in that place. But, according to the wise constitution of things, this must necessarily happen. The eruption of the fiery vapour from volcanos on the continent or land, is interrupted only occasionally, by the melted bodies flowing in the subterraneous chimney; whereas, at the bottom of the ocean, the contact of the water necessarily tends to close the orifice, by accumulating condensed matter upon the weakest place.

IF this be a just theory of the natural operations of the globe, we shall have reason to expect, that great quantities of this melted matter or fusible substance may be found in form of lava, among the strata of the earth, where there are no visible marks of any volcano, or burning mountain, having existed. Here, therefore, is an important point to be determined; for, if it shall appear, that much of this melted matter, analogous to lava, has been forced to flow among the strata which had been formed at the bottom of the sea, and now are found
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forming dry land above its surface, it will be allowed, that we have discovered the secret operations of nature concocting future land, as well as those by which the present habitable earth had been produced from the bottom of the abyfs. Here, therefore, we shall at present rest the argument, with endeavouring to shew that such is actually the case.

It appears from CRONSTEDT's Mineralogy, that the rockstone, called trap by the Swedes, the amygdaloides and the schwarts-stein of the Germans, are the same with the whinstone of this country. This is also fully confirmed by specimens from Sweden, sent me by my friend Dr GAHN. Whatever, therefore, shall be ascertained with regard to our whinstone, may be so far generalized or extended to the countries of Norway, Sweden, and Germany.

THE whinstone of Scotland is also the same with the toadstone of Derbyshire, which is of the amygdaloides species; it is also the same with the ragstone of the south of Staffordshire, which is a simple whinstone, or perfect trap. England, therefore, must be included in this great space of land, the mineral operations of which we explore; and also Ireland, of which the Giants Causeway, and many others, are sufficient proof.

IN the south of Scotland, there is a ridge of hills, which extends from the west side of the island in Galloway to the east side in Berwickshire, composed of granite, of schistus, and of siliceous strata. The Grampians on the north, again, form another range of mountains of the same kind; and between these two great fields of broken, tumbled and distorted strata, there lies a field of lesser hardness and consolidation, in general; but a field in which there is a great manifestation of subterraneous fire, and of exerted force.

THE strata in this space consist, in general, of sandstone, coal, limestone or marble, ironstone, and marl or argillaceous strata, with strata of analogous bodies, and the various compositions of these. But what is to the present purpose is this, that,

that, through all this space, there are interspersed immense quantities of whinstone; a body which is to be distinguished as very different from lava; and now the disposition of this whinstone is to be considered.

SOMETIMES it is found in an irregular mass or mountain, as Mr CRONSTEDT has properly observed; but he has also said, that this is not the case in general. His words are: "It is
" oftener found in form of veins in mountains of another
" kind, running commonly in a serpentine manner, contrary
" or across to the direction of the rock itself."

THE origin of this form, in which the trap or whinstone appears, is most evident to inspection, when we consider that this solid body had been in a fluid state, and introduced, in that state, among strata which preserved their proper form. The strata appear to have been broken, and the two correspondent parts of those strata are separated to admit the flowing mass of whinstone.

A FINE example of this kind may be seen upon the south side of the Earn, on the road to Crief. It is twenty-four yards wide, stands perpendicular, and appears many feet above the surface of the ground. It runs from that eastward, and would seem to be the same with that which crosses the river Tay, in forming Campsy-lin above Stanley, as a lesser one of the same kind does below it. I have seen it at Lednoc upon the Ammon, where it forms a cascade in that river, about five or six miles west of Campsy-lin. It appears to run from the Tay east through Strathmore, so that it may be considered as having been traced for twenty or thirty miles, and westwards to Drummond castle, perhaps much farther.

Two small veins of the same kind, only two or three feet wide, may be seen in the bed of the Water of Leith, traversing the horizontal strata, the one is above St BERNARD's well, the other immediately below it. But, more particularly, in the shire of Ayr, to the north of Irvine, there are to be seen upon
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the coast, between that and Scarmorly, in the space of about twenty miles, more than twenty or thirty such dykes (as they are called) of whinstone. Some of them are of a great thickness; and, in some places, there is perceived a short one, running at right angles, and communicating with other two that run parallel.

THERE is in this country, and in Derbyshire*, another regular appearance of this stone, which CRONSTEDT has not mentioned. In this case, the strata are not broken in order to have the whinstone introduced, they are separated, and the whinstone is interjected in form of strata, having various degrees of regularity, and being of different thickness. On the south side of Edinburgh, I have seen, in little more than the space of a mile from east to west, nine or ten masses of whinstone interjected among the strata. These masses of whinstone are from three or four to an hundred feet thick, running parallel in planes inclined to the horizon, and forming with it an angle of about twenty or thirty degrees, as may be seen at all times in the hill of Salisbury Craggs.

HAVING thus described these masses, which have flowed by means of heat among the strata of the globe, strata which had been formed by subsidence at the bottom of the sea, it will now be proper to examine the difference that subsists between these subterraneous lavas, as they may be termed, and the analogous bodies, which are proper lavas, in having issued out of a volcano†.

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* See Mr WHITEHURST's Theory of the Earth.

† The Chevalier de Dolomieu, in his accurate examination of *Ætna* and the *Lipari* islands, has very well observed the distinction of these two different species of lavas; but without seeming to know the principle upon which this essential difference depends. No bias of system, therefore, can here be supposed as perverting the Chevalier's view, in taking those observations; and these are interesting to the present theory, as corresponding perfectly with the facts from whence it has been formed. It will be proper to give the account of these in his own words.

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THERE can be no doubt that these two different species of bodies have had the same origin, and that they are composed of the same materials nearly; but from the different circumstances of their production, there is formed a character to these bodies, by which they may be perfectly distinguished. The difference of those circumstances consists in this; the one has been emitted to the atmosphere in its fluid state, the other only came to be exposed to the light in a long course of time, after it had congealed under the compression of an immense load of earth, and after certain operations, proper to the mineral regions, had been exercised upon the indurated mass. This is the cause of the difference between those erupted lavas, and our whinstone, toadstone, and the Swedish trap, which may be termed subterraneous lava. The visible effects of those different operations may now be mentioned.

IN the erupted lavas, those substances which are subject to calcine and vitrify in our fires, suffer similar changes, when delivered from a compression which had rendered them fixed, though

La zeolite est tres-commune dans certains laves de l'Etna; il seroit peut-être possible d'y en rencontrer des morceaux aussi gros que ceux que fournit l'île de Ferroé. Quoique cette substance semble ici appartenir aux laves, je ne dirai cependant point que toutes les zeolites soient volcaniques, ou unies à des matieres volcaniques; celles que l'on trouve en Allemagne sont, dit-on, dans des circonstances differentes; mais je doit annoncer que je n'ai trouvé cette substance en Sicile, que dans les seules laves qui évidemment ont coulé dans la mer, et qui ont été recouvertes par ses eaux. La zeolite des laves n'est point une dejection volcanique, ni une production du feu, ni même une matiere que les laves aient enveloppée lorsqu'elles étoient fluides; elle est le resultat d'une operation et d'une combinaison postérieure, auxquelles les eaux de la mer ont concouru. Les laves qui n'ont pas été submergées, n'en contiennent jamais. J'ai trouvé ces observations si constantes, que par-tout où je rencontrois de la zeolite, j'étois sûr de trouver d'autres preuves de submersion, et partout où je voyois des laves recouvertes des dépôts de l'eau, j'étois sûr de trouver de la zeolite, et un de ces faits m'a toujours indiqué l'autre. Je me suis servi avec succès de cette observation pour diriger mes recherches, et pour connoître l'antiquité des laves. *Mineralogie de Volcans, par M. Faujas de Saint-Fond.* Here would appear to be the distinction of subterraneous lava, in which zeolite and calcareous spar may be found, and that which has flowed from a volcano, in which neither of these are ever observed.

though in an extremely heated state. Thus, a lava in which there is much calcareous spar, when it comes to be exposed to the atmosphere, or delivered from the compressing force of its confinement, effervesces by the explosion of its fixed air; the calcareous earth, at the same time, vitrifies with the other substances: Hence such violent ebullition in volcanos, and hence the emission of so much pumice-stone and ashes, which are of the same nature.

IN the body of our whinstone, on the contrary, there is no mark of calcination or vitrification. We frequently find in it much calcareous spar, or the *terra calcarea aerata*, which had been in a melted state by heat, and had been crystallized by congelation into a sparry form. Such is the *lapis amygdaloides*, and many of our whinstone rocks, which contain pebbles crystallized and variously figured, both calcareous, siliceous, and of a mixture in which both these substances form distinct parts. The specimens of this kind, which I have from the whinstone or porphyry rock of the Calton-hill, exhibit every species of mineral operation, in forming jasper, figured agate, and marble; and they demonstrate, that this had been performed by heat or fusion.

I DO not mean to say, that this demonstration is direct; it is conditional, and proceeds upon the supposition, that the basaltic or porphyry rock, in which those specimens are found, is a body which had been in a melted state. Now, this is a supposition for which I have abundance of evidence, were it required; but naturalists are now sufficiently disposed to admit that proposition; they even draw conclusions from this fact, which, I think, they are not sufficiently warranted in doing; that is, from this appearance, they infer the former existence of volcanos in those places. For my part, though I have made the most strict examination, I never saw any vestige of such an event. That there are, in other countries, evident marks of volcanos which have been long extinguished, is unquestionably

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true ; but naturalists, imagining that there are no other marks of subterraneous fire and fusion, except in the production of a lava, attribute to a volcano, as a cause, these effects, which only indicate the exertion of that power which might have been the cause of a volcano.

If the theory now given be just, a rock of marble is no less a mark of subterraneous fire and fusion, than that of the basalt ; and the flowing of basaltic streams among strata broken and displaced, affords the most satisfactory evidence of those operations by which the body of our land had been elevated above the surface of the sea ; but it gives no proof that the eruptive force of mineral vapours had been discharged in a burning mountain. Now, this discharge is essential in the proper idea of a volcano.

BESIDES this internal mark of an unerupted lava in the substance of the stone or body of the flowing mass, there are others which belong to it in common with all other mineral strata, consolidated by subterraneous fire, and changed from the place of their original formation ; this is, the being broken and dislocated, and having veins of foreign matter formed in their separations and contractions.

If these are mineral operations, proper to the lower regions of the earth, and exerted upon bodies under immense compression, such things will be sometimes found in the unerupted lavas, as well as in the contiguous bodies with which they are associated. If, on the contrary, these are operations proper to the surface of the earth, where the dissolving power of water and air take place, and where certain stalactical and ferruginous concretions are produced by these means ; then, in erupted lavas, we should find mineral concretions, which concretions should be denied to bodies which had been consolidated at the bottom of the sea ; that is to say, where, without the operation of subterraneous fire, no changes of that kind could have taken place, as has already been observed. But in the unerupted species

cies of lava, that is to say, in our whinstone, every species of mineral appearance is occasionally to be found. Let those who have the opportunity to examine, say, what are to be found in proper lavas, that is, those of the erupted kind. Sir WILLIAM HAMILTON informed me, when I shewed him those mineral veins and spars in our whinstone, that he had never observed the like in lavas.

WE have now formed some conclusions with regard to the nature and production of those parts of the land of this globe which we have had the means of examining perfectly; but from the accounts of travellers, and from the specimens which are brought to us from distant parts, we have reason to believe, that all the rest of the earth is of the same nature with that which has been now considered. The great masses of the earth are the same every where; and all the different species of earths, of rocks or stone, which have as yet appeared, are to be found in the little space of this our island.

IT is true, that there are peculiar productions in the mineral kingdom which are rare, as being found only in few places; but these things are merely accidental in relation to the land, for they belong in property to those parts of the mineral region which we never see. Such are, the diamond of the east, the platina of the west, and the tin of Cornwall, Germany, and Sumatra. Gold and silver, though found in many countries, do not appear to be immediately necessary in the production of a habitable country. Iron, again, is universal in the operations of the globe, and is found often in that profusion which equals its utility. Between these two extremes, we find all other minerals, that is to say, here and there in moderate quantity, and apparently in some proportion to their use. But all these substances are to be considered as the vapours of the mineral regions, condensed occasionally in the crevices of the land; and it is only the rocks and strata (in which those mineral veins are found) that are now examined with regard to their original

composition at the bottom of the sea, as well as to that operation by which those bodies had been indurated in their substance, and elevated from the place in which they had been formed.

THUS, we have sufficient reason to believe, that, in knowing the construction of the land in Europe, we know the constitution of the land in every part of the globe. Therefore, we may proceed to form general conclusions, from the knowledge of the mineral region, thus acquired in studying those parts which are seen.

HAVING thus found, *first*, That the consolidated and indurated masses of our strata had suffered the effects of violent heat and fusion; *2dly*, That those strata, which had been formed in a regular manner at the bottom of the sea, have been violently bended, broken and removed from their original place and situation; and, *lastly*, Having now found the most indubitable proof, that the melting, breaking, and removing power of subterraneous fire, has been actually exerted upon this land which we examine, we cannot hesitate in ascribing these operations as a cause to those effects which are exposed to our view. Now, these may be considered as consisting in the solid state and present situation of those stratified bodies, originally formed by subsidence in the ocean; appearances which cannot, in reason, be ascribed to any other cause, and which, upon this principle, are perfectly explained.

It is not meant to specify every particular in the means employed by nature for the elevation of our land. It is sufficient to have shewn, that there is, in nature, means employed for the consolidating of strata, formed originally of loose and incoherent materials; and that those same means have also been employed in changing the place and situation of those strata. But how describe an operation which man cannot have any opportunity of perceiving? Or how imagine that, for which, perhaps, there are not proper data to be found? We only know, that the land

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is raised by a power which has for principle subterraneous heat ; but how that land is preserved in its elevated station, is a subject in which we have not even the means to form conjecture ; at least, we ought to be cautious how we indulge conjecture in a subject where no means occur for trying that which is but supposition.

WE now proceed, from the facts which have been properly established, to reason with regard to the duration of this globe, or the general view of its operations, as a living world, maintaining plants and animals.

P A R T IV.

System of Decay and Renovation observed in the Earth.

PHILOSOPHERS observing an apparent disorder and confusion in the solid parts of this globe, have been led to conclude, that there formerly existed a more regular and uniform state, in the constitution of this earth ; that there had happened some destructive change ; and that the original structure of the earth had been broken and disturbed by some violent operation, whether natural, or from a supernatural cause. Now, all these appearances, from which conclusions of this kind have been formed, find the most perfect explanation in the theory which we have been endeavouring to establish ; for they are the facts from whence we have reasoned, in discovering the nature and constitution of this earth : Therefore, there is no occasion for having recourse to any unnatural supposition of evil, to any destructive accident in nature, or to the agency of any preternatural cause, in explaining that which actually appears.

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It is necessary for a living or inhabited world, that this should consist of land and water. It is also necessary, that the land should be solid and stable, resisting, with great power, the violent efforts of the ocean ; and, at the same time, that this solid land should be resolved by the influence of the sun and atmosphere, so as to decay, and thus become a soil for vegetation. But these general intentions are perfectly fulfilled in the constitution of our earth, which has been now investigated. This great body being formed of different mixed masses, having various degrees of hardness and solubility, proper soil for plants is supplied from the gradual resolution of the solid parts ; fertility in those soils arises from the mixture of different elementary substances ; and stability is procured to that vegetable world, by the induration of certain bodies, those rocks and stones, which protect the softer masses of clay and soil.

IN this manner, also, will easily be explained those natural appearances which diversify the surface of the earth for the use of plants and animals, and those objects which beautify the face of nature for the contemplation of mankind. Such are, the distinctions of mountains and valleys, of lakes and rivers, of dry barren deserts and rich watered plains, of rocks which stand apparently unimpaired by the lapse of time, and sands which fluctuate with the winds and tides. All these are the effects of steady causes ; each of these has its proper purpose in the system of the earth ; and in that system is contained another, which is that of living growing bodies, and of animated beings.

BUT, besides this, man, the intellectual being, has, in this subject of the mineral kingdom, the means of gratifying the desire of knowledge, a faculty by which he is distinguished from the animal, and by which he improves his mind in knowing causes. Man is not satisfied, like the brute, in seeing things which are ; he seeks to know how things have been, and what they are to be. It is with pleasure that he observes order

order and regularity in the works of nature, instead of being disgusted with disorder and confusion; and he is made happy from the appearance of wisdom and benevolence in the design, instead of being left to suspect in the Author of nature, any of that imperfection which he finds in himself.

LET us now take a view of that system of mineral œconomy, in which may be perceived every mark of order and design, of provident wisdom and benevolence.

WE have been endeavouring to prove, that all the continents and islands of this globe had been raised above the surface of the ocean; we have also aimed at pointing out the cause of this translation of matter, as well as of the general solidity of that which is raised to our view; but however this theory shall be received, no person of observation can entertain a doubt, that all, or almost all we see of this earth, had been originally formed at the bottom of the sea. We have now another object in our view; this is to investigate the operations of the globe, at the time that the foundation of this land was laying in the waters of the ocean, and to trace the existence and the nature of things, before the present land appeared above the surface of the waters. We should thus acquire some knowledge of the system according to which this world is ruled, both in its preservation and production; and we might be thus enabled to judge, how far the mineral system of the world shall appear to be contrived with all the wisdom, which is so manifest in what are termed the animal and vegetable kingdoms.

IT must not be imagined that this undertaking is a thing unreasonable in its nature; or that it is a work necessarily beset with any unfurmountable difficulty; for, however imperfectly we may fulfil this end proposed, yet, so far as it is to natural causes that are to be ascribed the operations of former time, and so far as, from the present state of things, or knowledge of natural history, we have it in our power to reason from effect to cause, there are, in the constitution of the world, which we
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now examine, certain means to read the annals of a former earth.

THE object of enquiry being the operations of the globe, during the time that the present earth was forming at the bottom of the sea, we are now to take a very general view of nature, without descending into those particulars which so often occupy the speculations of naturalists, about the present state of things. We are not at present to enter into any discussion with regard to what are the primary and secondary mountains of the earth; we are not to consider what is the first, and what the last, in those things which now are seen; whatever is most ancient in the strata which we now examine, is supposed to be collecting at the bottom of the sea, during the period concerning which we are now to enquire.

WE have already considered those operations which had been necessary in forming our solid land, a body consisting of materials originally deposited at the bottom of the ocean; we are now to investigate the source from whence had come all those materials, from the collection of which the present land is formed; and from knowing the state in which those materials had existed, previously to their entering the composition of our strata, we shall learn something concerning the natural history of this world, while the present earth was forming in the sea.

WE have already observed, that all the strata of the earth are composed either from the calcareous relicts of sea animals, or from the collection of such materials as we find upon our shores. At a gross computation, there may perhaps be a fourth part of our solid land, which is composed from the matter that had belonged to those animals. Now, what a multitude of living creatures, what a quantity of animal œconomy must have been required for producing a body of calcareous matter which is interspersed throughout all the land of the globe, and which certainly forms a very considerable part of that mass!

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Therefore, in knowing how those animals had lived, or with what they had been fed, we shall have learned a most interesting part of the natural history of this earth; a part which it is necessary to have ascertained, in order to see the former operations of the globe, while preparing the materials of the present land. But, before entering upon this subject, let us examine the other materials of which our land is formed.

GRAVEL forms a part of those materials which compose our solid land; but gravel is no other than a collection of the fragments of solid stones worn round, or having their angular form destroyed by agitation in water, and the attrition upon each other, or upon similar hard bodies. Consequently, in finding masses of gravel in the composition of our land, we must conclude, that there had existed a former land, on which there had been transacted certain operations of wind and water, similar to those which are natural to the globe at present, and by which new gravel is continually prepared, as well as old gravel consumed or diminished by attrition upon our shores.

SAND is the material which enters, perhaps in greatest quantity, the composition of our land. But sand is no other than small fragments of hard and solid bodies, worn or rounded more or less by attrition; consequently, the same natural history of the earth, which is investigated from the masses of gravel, is also applicable to those masses of sand which we find forming so large a portion of our present land throughout all the earth.

CLAY is now to be considered as the last of those materials of which our strata are composed; but, in order to understand the nature of this ingredient, something must be premised.

CLAY is a mixture of different earths or hard substances, in an impalpable state. Those substances are chiefly the siliceous and aluminous earths. Other earths are occasionally mixed in clays, or perhaps always to be found in some small portion. But this does not affect the general character of clay; it only forms a special variety in the subject. A sensible or considera-

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ble portion of calcareous earth, in the composition of clay, constitutes a marl, and a sufficient admixture of sand, a loam.

AN indefinite variety of those compositions of clay form a large portion of the present strata, all indurated and consolidated in various degrees ; but this great quantity of siliceous, argillaceous, and other compound substances, in form of earth or impalpable sediment, corresponds perfectly with that quantity of those same substances which must have been prepared in the formation of so much gravel and sand, by the attrition of those bodies in the moving waters.

THEREFORE, from the consideration of those materials which compose the present land, we have reason to conclude, that, during the time this land was forming, by the collection of its materials at the bottom of the sea, there had been a former land containing materials similar to those which we find at present in examining the earth. We may also conclude, that there had been operations similar to those which we now find natural to the globe, and necessarily exerted in the actual formation of gravel, sand and clay. But what we have now chiefly in view to illustrate is this, that there had then been in the ocean a system of animated beings, which propagated their species, and which have thus continued their several races to this day.

IN order to be convinced of that truth, we have but to examine the strata of our earth, in which we find the remains of animals. In this examination, we not only discover every genus of animal which at present exists in the sea, but probably every species, and perhaps some species with which at present we are not acquainted. There are, indeed, varieties in those species, compared with the present animals which we examine, but no greater varieties than may perhaps be found among the same species in the different quarters of the globe. Therefore, the system of animal life, which had been maintained in the ancient sea, had not been different from that which now subsists, and of which it belongs to naturalists to know the history.

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It is the nature of animal life to be ultimately supported from matter of vegetable production. Inflammable matter may be considered as the *pabulum* of life. This is prepared in the bodies of living plants, particularly in their leaves exposed to the sun and light. This inflammable matter, on the contrary, is consumed in animal bodies, where it produces heat or light, or both. Therefore, however animal matter, or the *pabulum* of life, may circulate through a series of digesting powers, it is constantly impaired or diminishing in the course of this œconomy, and, without the productive power of plants, it would finally be extinguished.

THE animals of the former world must have been sustained during indefinite successions of ages. The mean quantity of animal matter, therefore, must have been preserved by vegetable production, and the natural waste of inflammable substance repaired with continual addition; that is to say, the quantity of inflammable matter necessary to the animal consumption, must have been provided by means of vegetation. Hence we must conclude, that there had been a world of plants, as well as an ocean replenished with living animals.

WE are now, in reasoning from principles, come to a point decisive of the question, and which will either confirm the theory, if it be just, or confute our reasoning, if we have erred. Let us, therefore, open the book of Nature, and read in her records, if there had been a world bearing plants, at the time when this present world was forming at the bottom of the sea.

HERE the cabinets of the curious are to be examined; but here some caution is required, in order to distinguish things perfectly different, which sometimes are confounded.

FOSSIL WOOD, to naturalists in general, is wood dug up from under ground, without enquiring whether this had been the production of the present earth, or that which had preceded it in the circulation of land and water. The question is important, and the solution of it is, in general, easy. The vege-

table productions of the present earth, however deep they may be found buried beneath its surface, and however ancient they may appear, compared with the records of our known times, are new, compared with the solid land on which they grew; and they are only covered with the produce of a vegetable soil, or the alluvion of the present land on which we dwell, and on which they had grown. But the fossil bodies which form the present subject of enquiry, belonged to former land, and are found only in the sea-born strata of our present earth. It is to these alone that we appeal, in order to prove the certainty of former events.

MINERALIZED wood, therefore, is the object now enquired after; that wood which had been lodged in the bottom of the sea, and there composed part of a stratum, which hitherto we have considered as only formed of the materials proper to the ocean. Now, what a profusion of this species of fossil wood is to be found in the cabinets of collectors, and even in the hands of lapidaries, and such artificers of polished stones! In some places, it would seem to be as common as the agate.

I SHALL only mention a specimen in my own collection. It is wood petrified with calcareous earth, and mineralized with pyrites. This specimen of wood contains in itself, even without the stratum of stone in which it is embedded, the most perfect record of its genealogy. It had been eaten or perforated by those sea-worms which destroy the bottoms of our ships. There is the clearest evidence of this truth. Therefore, this wood had grown upon land which stood above the level of the sea, while the present land was only forming at the bottom of the ocean.

WOOD is the most substantial part of plants, as shells are the more permanent part of marine animals. It is not, however, the woody part alone of the ancient vegetable world that is transmitted to us in the record of our mineral pages. We have the type of many species of foliage, and even of the most

most delicate flower ; for, in this way, naturalists have determined, according to the Linnæan system, the species, or at least the genus, of the plant. Thus, the existence of a vegetable system at the period now in contemplation, so far from being doubtful, is a matter of physical demonstration.

THE profusion of this vegetable matter, delivered into the ocean, which then generated land, is also evidenced in the amazing quantities of mineral coal, which is to be found in perhaps every region of the earth.

NOTHING can be more certain, than that all the coaly or bituminous strata have had their origin from the substance of vegetable bodies that grew upon the land. Those strata, though, in general, perfectly consolidated, often separate horizontally in certain places ; and there we find the fibrous or vascular structure of the vegetable bodies. Consequently, there is no doubt of fossil coal being a substance of vegetable production, however animal substances also may have contributed in forming this collection of oleaginous or inflammable matter.

HAVING thus ascertained the state of a former earth, in which plants and animals had lived, as well as the gradual production of the present earth, composed from the materials of a former world, it must be evident, that here are two operations which are necessarily consecutive. The formation of the present earth necessarily involves the destruction of continents in the ancient world ; and, by pursuing in our mind the natural operations of a former earth, we clearly see the origin of that land, by the fertility of which, we, and all the animated bodies of the sea, are fed. It is in like manner, that, contemplating the present operations of the globe, we may perceive the actual existence of those productive causes, which are now laying the foundation of land in the unfathomable regions of the sea, and which will, in time, give birth to future continents.

BUT though, in generalizing the operations of nature, we have arrived at those great events, which, at first sight, may fill

fill the mind with wonder and with doubt, we are not to suppose, that there is any violent exertion of power, such as is required in order to produce a great event in little time; in nature, we find no deficiency in respect of time, nor any limitation with regard to power. But time is not made to flow in vain; nor does there ever appear the exertion of superfluous power, or the manifestation of design, not calculated in wisdom to effect some general end.

THE events now under consideration may be examined with a view to see this truth; for it may be enquired, why destroy one continent in order to erect another? The answer is plain; Nature does not destroy a continent from having wearied of a subject which had given pleasure, or changed her purpose, whether for a better or a worse; neither does she erect a continent of land among the clouds, to shew her power, or to amaze the vulgar man: Nature has contrived the productions of vegetable bodies, and the sustenance of animal life, to depend upon the gradual but sure destruction of a continent; that is to say, these two operations necessarily go hand in hand. But with such wisdom has nature ordered things in the œconomy of this world, that the destruction of one continent is not brought about without the renovation of the earth in the production of another; and the animal and vegetable bodies, for which the world above the surface of the sea is levelled with its bottom, are among the means employed in those operations, as well as the sustenance of those living beings is the proper end in view.

THUS, in understanding the proper constitution of the present earth, we are led to know the source from whence had come all the materials which nature had employed in the construction of the world which appears; a world contrived in consummate wisdom for the growth and habitation of a great diversity of plants and animals; and a world peculiarly adapted to

to the purposes of man, who inhabits all its climates, who measures its extent, and determines its productions at his pleasure.

THE whole of a great object or event fills us with wonder and astonishment, when all the particulars, in the succession of which the whole had been produced, may be considered without the least emotion. When, for example, we behold the pyramids of Egypt, our mind is agitated with a crowd of ideas that highly entertains the person who understands the subject; but the carrying a heavy stone up to the top of a hill or mountain would give that person little pleasure or concern. We wonder at the whole operation of the pyramid, but not at any one particular part.

THE raising up of a continent of land from the bottom of the sea, is an idea that is too great to be conceived easily in all the parts of its operation, many of which are perhaps unknown to us; and without being properly understood, so great an idea may appear like a thing that is imaginary. In like manner, the co-relative, or corresponding operation, the destruction of the land, is an idea that does not easily enter into the mind of man in its totality, although he is daily witness to part of the operation. We never see a river in a flood, but we must acknowledge the carrying away of part of our land, to be sunk at the bottom of the sea; we never see a storm upon the coast, but we are informed of a hostile attack of the sea upon our country; attacks which must, in time, wear away the bulwarks of our soil, and sap the foundations of our dwellings. Thus, great things are not understood without the analyzing of many operations, and the combination of time with many events happening in succession.

LET us now consider what is to be the subject of examination, and where it is that we are to observe those operations which must determine either the stability or the instability of this land on which we live.

OUR

OUR land has two extremities ; the tops of the mountains, on the one hand, and the sea-shores, on the other : It is the intermediate space between these two, that forms the habitation of plants and animals. While there is a sea-shore and a higher ground, there is that which is required in the system of the world : Take these away, and there would remain an aqueous globe, in which the world would perish. But, in the natural operations of the world, the land is perishing continually ; and this is that which now we want to understand.

UPON the one extremity of our land, there is no increase, or there is no accession of any mineral substance. That place is the mountain-top, on which nothing is observed but continual decay. The fragments of the mountain are removed in a gradual succession from the highest station to the lowest. Being arrived at the shore, and having entered the dominion of the waves, in which they find perpetual agitation, these hard fragments, which had eluded the resolving powers natural to the surface of the earth, are incapable of resisting the powers here employed for the destruction of the land. By the attrition of one hard body upon another, the moving stones and rocky shore, are mutually impaired. And that solid mass, which of itself had potential stability against the violence of the waves, affords the instruments of its own destruction, and thus gives occasion to its actual instability.

IN order to understand the system of the heavens, it is necessary to connect together periods of measured time, and the distinguished places of revolving bodies. It is thus that system may be observed, or wisdom, in the proper adapting of powers to an intention. In like manner, we cannot understand the system of the globe, without seeing that progress of things which is brought about in time, thus measuring the natural operations of the earth with those of the heavens. This is properly the business of the present undertaking.

OUR

OUR object is to know the time which had elapsed since the foundation of the present continent had been laid at the bottom of the ocean, to the present moment in which we speculate on these operations. The space is long ; the data for the calculations are, perhaps, deficient : No matter ; so far as we know our error, or the deficiency in our operation, we proceed in science, and shall conclude in reason. It is not given to man to know what things are truly in themselves, but only what those things are in his thought. We seek not to know the precise measure of any thing ; we only understand the limits of a thing, in knowing what it is not, either on the one side or the other.

WE are investigating the age of the present earth, from the beginning of that body which was in the bottom of the sea, to the perfection of its nature, which we consider as in the moment of our existence ; and we have necessarily another æra, which is collateral, or correspondent, in the progress of those natural events. This is the time required, in the natural operations of this globe, for the destruction of a former earth ; an earth equally perfect with the present, and an earth equally productive of growing plants and living animals. Now, it must appear, that, if we had a measure for the one of those corresponding operations, we would have an equal knowledge of the other.

THE formation of a future earth being in the bottom of the ocean, at depths unfathomable to man, and in regions far beyond the reach of his observation, here is a part of the process which cannot be taken as a principle in forming an estimate of the whole. But, in the destruction of the present earth, we have a process that is performed within the limits of our observation ; therefore, in knowing the measure of this operation, we shall find the means of calculating what had passed on a former occasion, as well as what will happen in the

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composition

composition of a future earth. Let us, therefore, now attempt to make this estimate of time and labour.

THE highest mountain may be levelled with the plain from whence it springs, without the loss of real territory in the land; but when the ocean makes encroachment on the basis of our earth, the mountain, unsupported, tumbles with its weight; and with that accession of hard bodies, moveable with the agitation of the waves, gives to the sea the power of undermining farther and farther into the solid basis of our land. This is the operation which is to be measured; this is the mean proportional by which we are to estimate the age of worlds that have terminated, and the duration of those that are but beginning.

BUT how shall we measure the decrease of our land? Every revolution of the globe wears away some part of some rock upon some coast; but the quantity of that decrease, in that measured time, is not a measurable thing. Instead of a revolution of the globe, let us take an age. The age of man does no more in this estimate than a single year. He sees, that the natural course of things is to wear away the coast, with the attrition of the sand and stones upon the shore; but he cannot find a measure for this quantity which shall correspond to time, in order to form an estimate of the rate of this decrease.

BUT man is not confined to what he sees; he has the experience of former men. Let us then go to the Romans and the Greeks in search of a measure of our coasts, which we may compare with the present state of things. Here, again, we are disappointed; their descriptions of the shores of Greece and of Italy, and their works upon the coast, either give no measure of a decrease, or are not accurate enough for such a purpose.

IT is in vain to attempt to measure a quantity which escapes our notice, and which history cannot ascertain; and we might just as well attempt to measure the distance of the stars without

out a parallax, as to calculate the destruction of the solid land without a measure corresponding to the whole.

THE description which POLYBIUS has given of the Pontus Euxinus, with the two opposite Bosphori, the Meotis, the Propontis, and the Port of Byzantium, are as applicable to the present state of things, as they were at the writing of that history. The filling up of the bed of the Meotis, an event which, to POLYBIUS, appeared not far off, must also be considered as removed to a very distant period, though the causes still continue to operate as before.

BUT there is a thing in which history and the present state of things do not agree. It is upon the coast of Spain, where POLYBIUS says there was an island in the mouth of the harbour of New Carthage. At present, in place of the island, there is only a rock under the surface of the water. It must be evident, however, that the loss of this small island affords no proper ground of calculation for the measure or rate of wasting which could correspond to the coast in general; as neither the quantity of what is now lost had been measured, nor its quality ascertained.

LET us examine places much more exposed to the fury of the waves and currents than the coast of Carthage, the narrow fretum, for example, between Italy and Sicily. It does not appear, that this passage is sensibly wider than when the Romans first had known it. The Isthmus of Corinth is also apparently the same at present as it had been two or three thousand years ago. Scilla and Charibdis remain now, as they had been in ancient times, rocks hazardous for coasting vessels which had to pass that strait.

It is not meant by this to say, these rocks have not been wasted by the sea, and worn by the attrition of moving bodies, during that space of time; were this true, and that those rocks, the bulwarks of the land upon those coasts, had not been at all impaired from that period, they might remain

for ever, and thus the system of interchanging the place of sea and land upon this globe might be frustrated. It is only meant to affirm, that the quantity which those rocks, or that coast, have diminished from the period of our history, has either been too small a thing for human observation, or, which is more probable, that no accurate measurement of the subject, by which this quantity of decrease might have been ascertained, had been taken and recorded. It must be also evident, that a very small operation of an earthquake would be sufficient to render every means of information, in this manner of mensuration, unsatisfactory or precarious.

PLINY says Italy was distant from Sicily a mile and a half; but we cannot suppose that this measure was taken any other-wise than by computation, and such a measure is but little calculated to afford us the just means of a comparison with the present distance. He also says, indeed, that Sicily had been once joined with Italy. His words are: "*Quondam BRUTIO agro cohærens, mox interfuso mari avulsa* *." But all that we can conclude from this history of PLINY is, that, in all times, to people considering the appearances of those two approached coasts, it had seemed probable, that the sea formed a passage between the two countries which had been once united; in like manner as is still more immediately perceived, in that smaller disjunction which is made between the island of Anglesey and the continent of Wales.

THE port of Syracuse, with the island which forms the greater and lesser, and the fountain of Arethusa, the water of which the ancients divided from the sea with a wall, do not seem to be altered. From Sicily to the coast of Egypt, there is an uninterrupted course of sea for a thousand miles; consequently, the wind, in such a stretch of sea, should bring powerful waves against those coasts. But, on this coast of Egypt, we find the rock on which was formerly built the famous tower of Pharos; and

* Lib. 3. cap. 8.

and also, at the eastern extremity of the port Eunoste, the sea-bath, cut in the solid rock upon the shore. Both those rocks, buffeted immediately with the waves of the Mediterranean sea, are, to all appearance, the same at this day as they were in ancient times *.

MANY other such proofs will certainly occur, where the different parts of those coasts are examined by people of observation and intelligence. But it is enough for our present purpose, that this decrease of the coasts in general has not been observed; and that it is as generally thought, that the land is gaining upon the sea, as that the sea is gaining upon the land.

To sum up the argument, we are certain, that all the coasts of the present continents are wasted by the sea, and constantly wearing away upon the whole; but this operation is so extremely slow, that we cannot find a measure of the quantity in order to form an estimate. Therefore, the present continents of the earth, which we consider as in a state of perfection, would, in the natural operations of the globe, require a time indefinite for their destruction.

BUT, in order to produce the present continents, the destruction of a former vegetable world was necessary; consequently, the production of our present continents must have required a time which is indefinite. In like manner, if the former continents were of the same nature as the present, it must have required another space of time, which also is indefinite, before they had come to their perfection as a vegetable world.

WE have been representing the system of this earth as proceeding with a certain regularity, which is not perhaps in nature, but which is necessary for our clear conception of the system of nature. The system of nature is certainly in rule, although we may not know every circumstance of its regulation. We are under a necessity, therefore, of making regular suppositions,

* Lettres sur l'Egypte, M. SAVARY.

suppositions, in order to come at certain conclusions which may be compared with the present state of things.

It is not necessary that the present land should be worn away and wasted, exactly in proportion as new land shall appear; or, conversely, that an equal proportion of new land should always be produced as the old is made to disappear. It is only required, that, at all times, there should be a just proportion of land and water upon the surface of the globe, for the purpose of a habitable world.

NEITHER is it required in the actual system of this earth, that every part of the land should be dissolved in its structure, and worn away by attrition, so as to be floated in the sea. Parts of the land may often sink in a body below the level of the sea, and parts again may be restored, without waiting for the general circulation of land and water, which proceeds with all the certainty of nature, but which advances with an imperceptible progression. Many of such apparent irregularities may appear, without the least infringement on the general system. That system is comprehended in the preparation of future land at the bottom of the ocean, from those materials which the dissolution and attrition of the present land may have provided, and from those which the natural operations of the sea afford.

In thus accomplishing a certain end, we are not to limit nature with the uniformity of an equable progression, although it be necessary in our computations to proceed upon equalities. Thus also, in the use of means, we are not to prescribe to nature those alone which we think suitable for the purpose, in our narrow view. It is our business to learn of nature (that is by observation) the ways and means, which in her wisdom are adopted; and we are to imagine these only in order to find means for further information, and to increase our knowledge from the examination of things which actually have been. It is in this manner, that intention may be found in nature; but
this

this intention is not to be supposed, or vainly imagined, from what we may conceive to be.

WE have been now supposing, that the beginning of our present earth had been laid in the bottom of the ocean, at the completion of the former land ; but this was only for the sake of distinctness. The just view is this, that when the former land of the globe had been complete, so as to begin to waste and be impaired by the encroachment of the sea, the present land began to appear above the surface of the ocean. In this manner we suppose a due proportion to be always preserved of land and water upon the surface of the globe, for the purpose of a habitable world, such as this which we possess. We thus, also, allow time and opportunity for the translation of animals and plants to occupy the earth.

BUT, if the earth on which we live, began to appear in the ocean at the time when the last began to be resolved, it could not be from the materials of the continent immediately preceding this which we examine, that the present earth had been constructed ; for the bottom of the ocean must have been filled with materials before land could be made to appear above its surface.

LET us suppose that the continent, which is to succeed our land, is at present beginning to appear above the water in the middle of the Pacific Ocean, it must be evident, that the materials of this great body, which is formed and ready to be brought forth, must have been collected from the destruction of an earth which does not now appear. Consequently, in this true statement of the case, there is necessarily required the destruction of an animal and vegetable earth prior to the former land ; and the materials of that earth which is first in our account, must have been collected at the bottom of the ocean, and begun to be concocted for the production of the present earth, when the land immediately preceding the present had arrived at its full extent.

THIS,

THIS, however, alters nothing with regard to the nature of those operations of the globe. The system is still the same. It only protracts the indefinite space of time in its existence, while it gives us a view of another distinct period of the living world; that is to say, the world which we inhabit is composed of the materials, not of the earth which was the immediate predecessor of the present, but of the earth which, in ascending from the present, we consider as the third, and which had preceded the land that was above the surface of the sea, while our present land was yet beneath the water of the ocean. Here are three distinct successive periods of existence, and each of these is, in our measurement of time, a thing of indefinite duration.

WE have now got to the end of our reasoning; we have no data further to conclude immediately from that which actually is: But we have got enough; we have the satisfaction to find, that in nature there is wisdom, system, and consistency. For having, in the natural history of this earth, seen a succession of worlds, we may from this conclude that there is a system in nature; in like manner as, from seeing revolutions of the planets, it is concluded, that there is a system by which they are intended to continue those revolutions. But if the succession of worlds is established in the system of nature, it is in vain to look for any thing higher in the origin of the earth. The result, therefore, of our present enquiry is, that we find no vestige of a beginning,—no prospect of an end.

EXPLANATION OF PLATE I. THEORY OF THE EARTH.

The 1. Section of the horizontal separation, cut horizontally, as
it is in the soil.

The 2. Another separation, cut both horizontally and vertically,
distantly.

The 3. Part of a separation, the divisions of which are more
in the distance.

All these three are of the same dimensions with the
figures.

The 4. Part of the 3, representing the part indicated with
a, b, c, which is magnified, in order to show the
crystalline cavity of the soil.

EXPLANATION of PLATE I. THEORY of the EARTH.

FIG. 1. Section of an iron-stone septarium, cut horizontally, as it lies in its bed.

FIG. 2. Another septarium, cut both horizontally and perpendicularly.

FIG. 3. Part of a septarium, the divisions of which are more in straight lines.

All these three are of the same dimensions with the specimens.

FIG. 4. Part of Fig. 3. representing the portion included within *a, b, c, d, e*, which is magnified, in order to show the crystallised cavity of the septa.

FIG. 1.

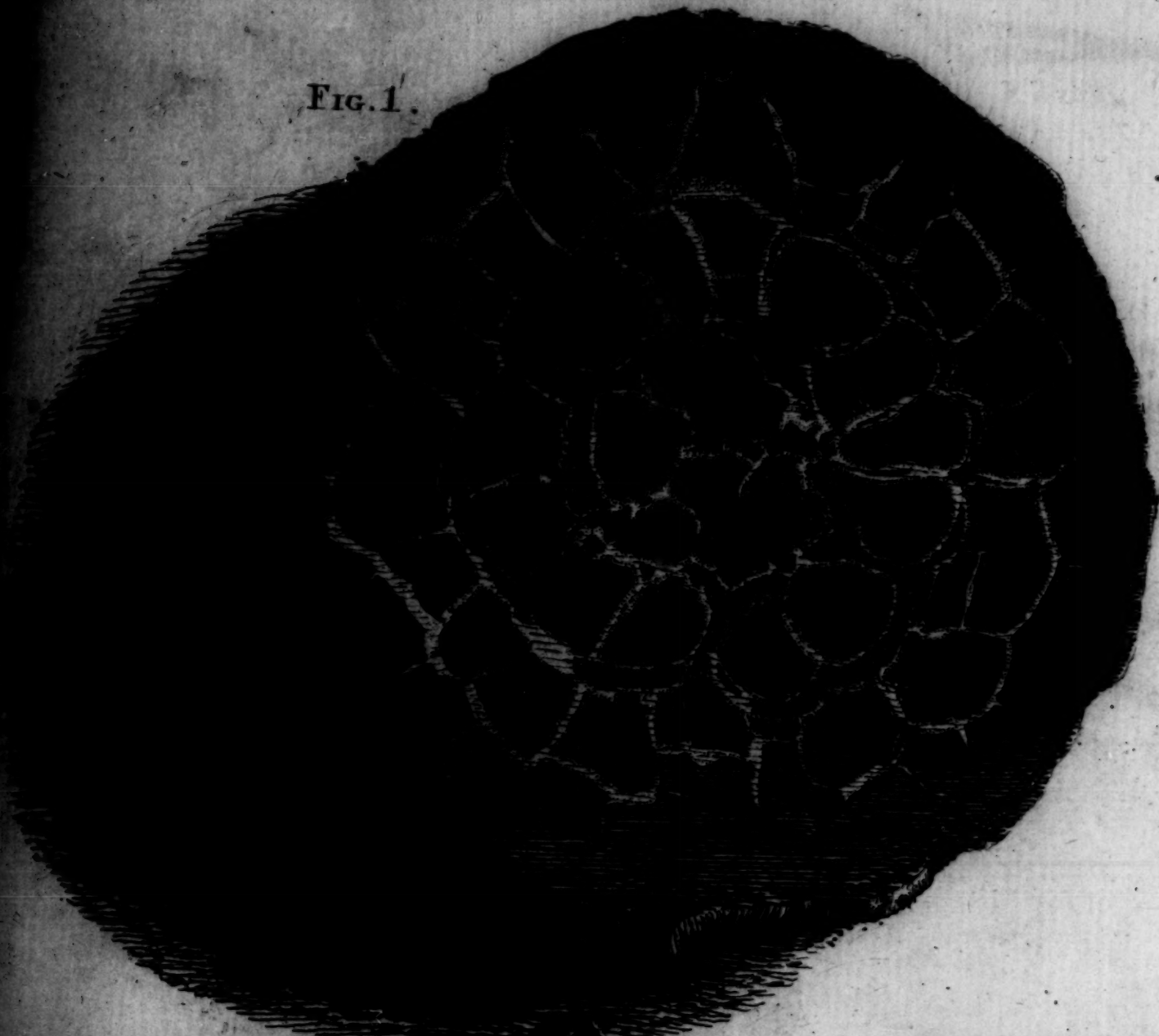


FIG. 3.



FIG. 4.



FIG. 2.





FIG. 1.

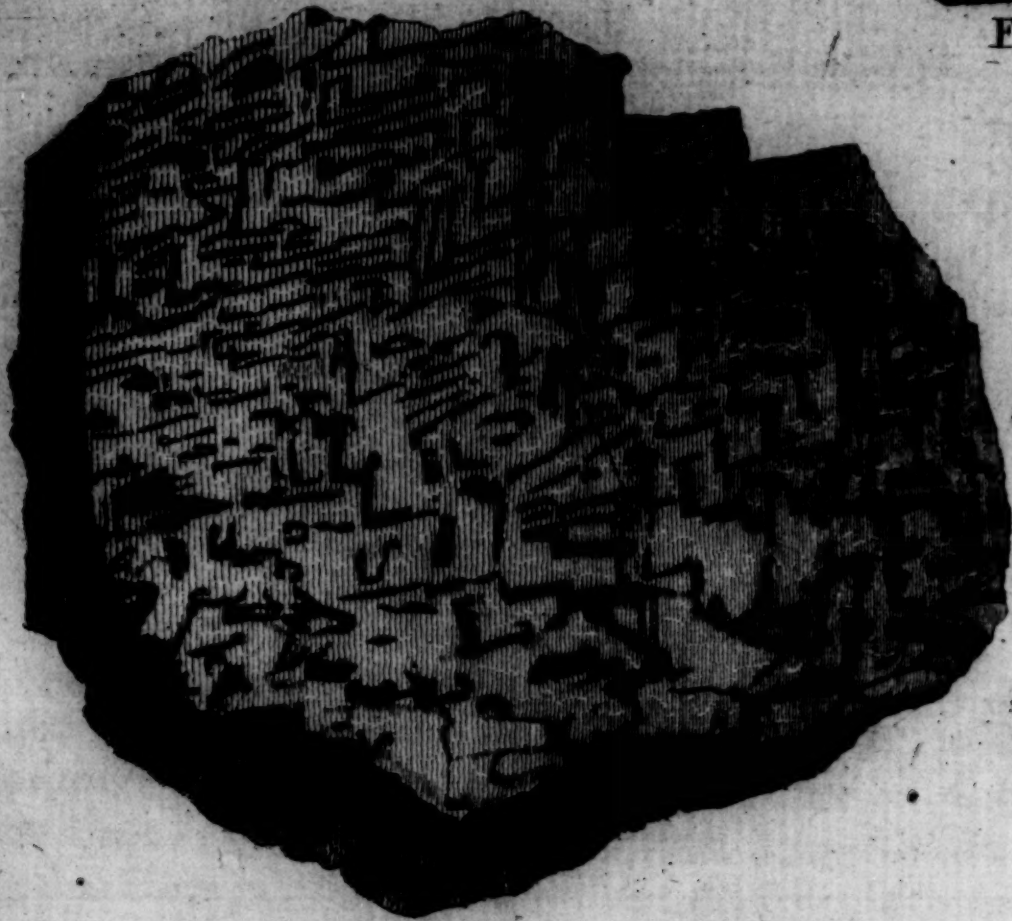


FIG. 8.



FIG. 9.

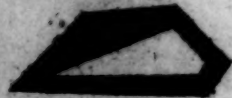


FIG. 10.



FIG. 5.

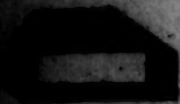


FIG. 6.



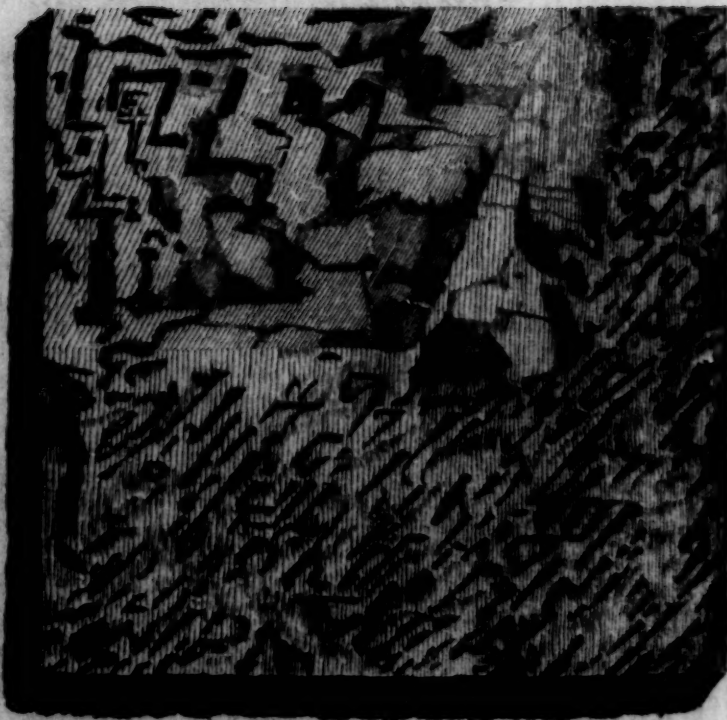
FIG. 7.

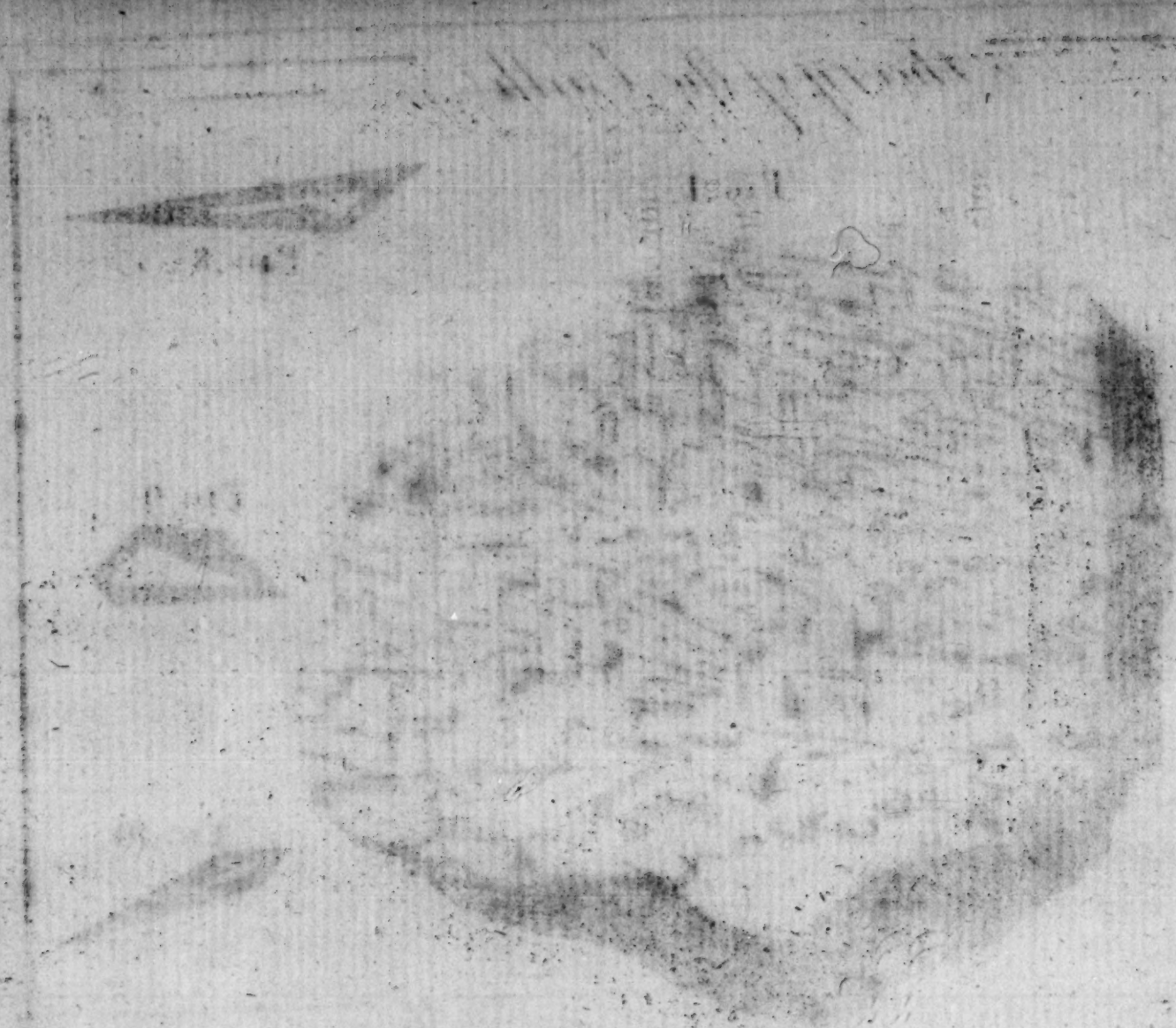


FIG. 2.



FIG. 3.





XI. *The ORBIT and MOTION of the GEORGIUM SIDUS determined directly from Observations, after a very easy and simple Method.* By JOHN ROBISON, M. A. F. R. S. EDIN. and Professor of Natural Philosophy in the University of EDINBURGH.

[Read by the Author, March 6. 1786.]

THE accuracy of modern observations has discovered irregularities in the motions of Jupiter and Saturn, which our knowledge of the laws of planetary gravitation has not as yet enabled us to explain. I have, therefore, long thought it probable that there may be planets without the orbit of Saturn, of sufficient magnitude to occasion these irregularities. This conjecture is confirmed by the discovery of a new planet.

ON the 13th of March 1781, Mr HERSCHEL, an astronomer of great ardour and ingenuity, observed a Star, near the foot of Castor, whose steady light attracted his attention. He immediately applied to his telescope a higher magnifying power, and discovered an augmentation of its apparent diameter. Two days after, he observed that it had changed its place; and, taking it for a comet, he wrote an account of his observation to Dr MASKELYNE, Astronomer-royal, who got sight of this Star on the 17th of March. An account of this discovery was soon given to the other astronomers of Europe, who have continued to observe it with unceasing attention. I did not obtain a sight of it till August 1782.

ALMOST at its first appearance, the English astronomers supposed it to be a Planet. They were led to this opinion by various circumstances which rendered it very probable; such as,

its vicinity to the Ecliptic, the direction of its motion, and its being nearly stationary at the time of its discovery, in such an aspect with respect to the Sun, as corresponds to the stationary appearance of the Planets. The French astronomers imagined it a Comet, although it had not that train of faint light which usually distinguishes those bodies; and, in the course of the year 1781, endeavoured to determine the elements of its motion on this supposition, but could not find out such as would correspond with its successive appearances. They at last found themselves obliged to suppose, that it moved round the Sun in an orbit nearly circular. Mr LEXEL, Professor of astronomy at St Petersburg, was the first who attempted a computation of its motion on this principle; and showed that a circular orbit, the radius of which is about nineteen times the distance of the earth from the sun, would very nearly agree with all the observations made during the year 1781. The first distinct information which I got of it was in June 1782, from Mr MINTO, a gentleman of this place, who communicated to me a series of excellent observations made by Professor SLOP at Pisa. This series contained the means of determining with accuracy the stationary points of the Planet in October 1781 and March 1782, and its opposition in December 1781. From these, I was enabled to ascertain with great ease, the radius of its circular orbit. For, at its stationary appearance, we have the square of the cosine of its elongation from the Sun = $\frac{r^2 - 1}{r^3 - 1}$, r being the radius, and the earth's mean distance being 1. The opposition in December 1781, gives us one place of the Planet as viewed from the Sun, independent of all hypotheses. With these data, it was easy for me to determine the apparent place of the Star for any time, and compare it with observation; and the result of this comparison was such as to show, that the opinion was very nearly true, the greatest errors not amounting to

to more than what might reasonably be attributed to the inaccuracy of observation.

ASTRONOMERS were every where engaged in the same research; and it occurred to some of them, that the Star might possibly have been observed before, by those who were employed in making catalogues of the Zodiacal Stars. Mr BODE of Berlin had just published a valuable work, in which all the catalogues of the Stars were included. He had recourse to his papers, where he had marked all the difference of these catalogues, in order to discover whether any Star, observed by one astronomer, and omitted by another, might not be this Star of Mr HERSCHEL, paying attention to those differences only which he could find in the parts of the Zodiac, through which the nearly determined orbit of this newly discovered Planet might be supposed to pass. Among others, he found the Star, No. 964. of MAYER's Catalogue, not observed by others, and but once observed by MAYER, who could not therefore discover any motion in it. Mr BODE immediately examined the heavens, and could not find this Star. He farther found, that the elements of the new Planet assigned to it that very apparent place, in the month of September 1756, one of the years in which MAYER was occupied with these observations. On examining the register of MAYER's observations, it was found, that he had observed the Star, No. 964. on the 25th of September 1756. This was notified to Mr BODE, in September 1781. He immediately made this information public; and it has since been currently supposed, that the Star observed by MAYER was the Planet of HERSCHEL.

It was found, even before the end of 1782, that the circular hypothesis was not exact, and that the angular motion of the Planet round the Sun was increasing. This showed, that the Planet was not moving in a circle, but in an excentric orbit, and was approaching to the Sun. Astronomers, therefore, began to investigate the inequality of this angular heliocentric motion, in order to discover the form and position of the ellipse

described by the Planet. This was a very difficult task; for the very small inequality of the motion showed that the orbit was nearly circular; and the arch already described was not much more than the fiftieth part of the whole circumference. The solution of the problem requires us to determine, from the variation of curvature discoverable in this small arch, to what part of the circumference it belongs. This requires the utmost accuracy in the observations, and great sagacity in making deductions from them*. But, taking it for granted that the 964th Star of MAYER's Catalogue was the new Planet, the problem becomes susceptible of a very easy solution; for that Star is situated more than a quarter of a revolution from the place of the Planet in 1782, and so fortunately, that almost the whole effect of the excentricity and inequality of the motion is accumulated. Astronomers, therefore, availed themselves of this observation of Mr BODE, and quickly found, by repeated trials, elements of the motions, which corresponded perfectly with MAYER's observation, and all those made since Mr HERSCHEL first got sight of the Planet. But they do not all seem disposed to confess their obligation to Mr BODE. Some of them affect to have deduced their elements directly from observations, by the formulæ expressive of the elliptical motion of the Planets, and to be agreeably surpris'd with afterwards observing the coincidence of their elements with this observation of MAYER. They have not given a detail of their methods of investigation.

OF

* THE first person who obtained any direct information of the elliptical orbit of the Planet was the celebrated Abbé Boscovich, who, in October or November 1781, deduced elements of its orbit from the observations of Mr MECHAIN. His method is exceedingly ingenious, and remarkable for that simplicity and geometrical elegance which characterise all his performances. It did not come to my knowledge till the beginning of this present year 1787, when I found it in the Collection which he published at Bassano, in 1785, in five volumes. He makes use of the same physical principles which I employed in January 1783, to determine the orbit by the two oppositions which had then been observed, combined with another observation, made at the distance of a sydereal year from one of the oppositions. This method I communicated to Dr MASKELYNE in 1783.

OF all the theories of this Planet which I have seen, that of M. DE LA PLACE, communicated to the Royal Academy of Sciences at Paris, appears the most accurate, and very nearly corresponds to the observations which have been made since the time of its publication. This theory was announced to the public in the *Connoissance des Mouvements Celestes*, as deduced directly from the recent observations, by a method peculiar to M. DE LA PLACE. This I hoped to find in an excellent dissertation on the elliptical motion of the Planets, published by him in 1784. But, although I found this work full of new and valuable information, as might be expected from this eminent mathematician, I was disappointed in my hopes of learning the process by which he had deduced his theory of the new Planet. He has, indeed, inserted in this work the elements of its orbit, and the four observations which he had employed for determining them, by a new method of considering the planetary motions, with which he was then occupied, but which he does not explain. When I compared M. DE LA PLACE's theory with those observations, I found such differences as would have allowed him to make choice of elements considerably different. It appears, therefore, that, before applying his method, he has corrected the observations on some justifiable principle, which I regret exceedingly that he has not communicated, since he has been so successful in the use of it. It would, doubtless, have been much more deserving of the notice of mathematicians than the empirical one which I have adopted in the subsequent part of this paper.

IN spring 1784, I framed a set of elements which corresponded with the observations made at that time with abundant accuracy. Mr MINTO, whom I have already mentioned, also communicated to me elements, little differing from mine, and equally accurate. Both these were deduced from a supposition that the Star observed by MAYER was the new Planet. We had, by this time, great advantages over our predecessors; for a
much

much larger portion of the arch had been observed; and, which was of immense consequence, three oppositions had been observed, which gave us three positions of the Planet, independent of all hypotheses. The arches described between these oppositions being thus determined, free from all uncertainty, the acceleration of the Planet's motion became known; and a method now offered of determining, by interpolation, its heliocentric place, at any intermediate moment, with very great accuracy. And now, by chusing such observations of the Star as should give a great difference between the heliocentric and geocentric place, the radius of the earth's orbit became a base, by which we could measure, with considerable accuracy, its distance from the Sun. Thus, having both its position and distance from the Sun, we could assign its absolute place in the heavens, and consequently the form of its path.

IN the beginning of 1785, another opposition was observed, and thus a method obtained of deducing the elements directly. But this required a process so extremely complicated, in order to obtain tolerable accuracy in the result, that I had not the courage to attempt it. I waited patiently till a fifth opposition should be observed with four intercepted arches. This, I saw, would afford a method extremely simple and easy, and, at the same time, susceptible of considerable accuracy. It is this method which I have now the honour to lay before this Society; and I hope that the Gentlemen who hear me will not think it altogether unworthy of their attention: For it is surely desirable not to rest our knowledge of the motions of this Planet on mere conjecture, whatever probability there may be of its truth from the coincidence of observations. I must, at the same time, acknowledge beforehand, that the result of my investigation has not enabled me to determine the elements of its motion with perfect certainty. It has, on the contrary, convinced me, that, if we do not admit that the new Planet is the same with

964 of *MAYER*, near half a century must elapse before the elements of its motion can be determined with a precision equal to that which is attained in the case of the other Planets. But the method assigns certain limits, and these not very wide, within which all the circumstances of its motion must be comprehended. This alone must be regarded as a considerable attainment.

THE heliocentric place of the Planet in opposition to the Sun, on the 21st of December 1781, was determined by me, from observations made on the 19th and 28th of that month, by Dr *MASKELYNE*, combined with observations made by Professor *SLOP* at Pisa, on the 22d, 23d, 27th, and 28th. The heliocentric place at the opposition 1782, was determined from observations made by Dr *MASKELYNE* on the 14th and 28th of December, combined with those of Professor *SLOP* on the 22d, 25th, and 26th of that month. The place of opposition in 1783 was determined from my own observations on the 26th, 27th, 28th of December, and the 5th of January following. The place at opposition January 3d 1785, was determined from my own observations on the 28th and 29th of December, and the 1st and 6th of January. The place at opposition 1786, was determined from my own observations on the 29th, 30th, and 31st of December, and the 1st, 3d, and 8th of January. The method which I took for combining these observations, in order to get rid of the inaccuracy to which each of them was liable, was as follows: The arch described between any two successive oppositions gave me a pretty near approximation to the distance of the Planet from the Sun, by means of the Keplerian law, that the squares of the angular motions are inversely as the cubes of the distances. The heliocentric angular motion, at any opposition, must be very nearly a medium between the angular motions with which the arches, intercepted between it and the preceding and following opposition, would be uniformly described. Thus I obtained, with sufficient accuracy,

curacy, the heliocentric angular motion at the three intermediate oppositions. The angular velocities at the two extreme oppositions were determined with equal accuracy, by supposing, that the changes of angular velocity followed a regular law. Thus I was enabled to determine the geocentric motion for a few days before and after opposition, and consequently to assign, from each observation, the precise time and place where the Planet would be in opposition to the Sun. These determinations differed from each other in no case 10". It is demonstrable, that the assumptions made for this combination of observations could not produce an error of 2". I therefore, with confidence, took the means of these determinations for the places of the Planet, in its apparent oppositions to the Sun.

THE times and apparent longitudes and latitudes of the Planet are expressed in the following table :

	M. T. Ed.	Long.	Lat. N.
	<i>b.</i> ' "	<i>s.</i> ' "	' "
1781. Dec. 21.	17. 44. 33	3. 00. 52. 11	15. 07
1782. Dec. 26.	08. 56. 56	3. 05. 20. 29	18. 56
1783. Dec. 31.	00. 46. 24	3. 09. 50. 52	22. 10
1785. Jan. 3.	17. 28. 56	3. 14. 23. 02	25. 40
1786. Jan. 8.	10. 39. 31	3. 18. 57. 05	28. 52

My manner of observing obliged me to compare the Planet with two fixed Stars which did not differ from it, or from each other, more than one degree in declination. This obliged me to employ some Stars which are to be found in MAYER's Catalogue alone. I have, therefore, always made use of this Catalogue. If, therefore, the following theory be confronted with an observation, where the geocentric place of the Planet is deduced from a comparison of it with a Star *in its neighbourhood*, and if the place of this Star be deduced from BRADLEY's, or DE LA CAILLE's Catalogues, the longitude will be found about 6" too small, or as much too great.

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THE manner of observation, and the instrument which I make use of, appear to me to have several advantages which are not unworthy of the attention of Astronomers. An account of them will therefore be communicated on some future occasion.

FROM these places, it is easy to determine the inclination of the Planet's orbit to the plane of the Ecliptic, and the place of its Node, which are as follow :

Long. Node, Jan. 1. 1786.	^{s.} [°] ["] [']
	2. 12. 48. 45
Inclin. Orbit,	46. 26

I WAS now enabled to reduce these Ecliptic places to the orbit itself, and thus to determine the arches of this orbit described during the intervals between the oppositions.

I THEN took the opposition which was observed on the 31st of December 1783 for an epoch, to which all the observations should be reduced. The interval of time between this and the preceding opposition was 369 *d.* 15 *b.* 49'. 28". I counted back another equal interval, which brought me within a few minutes of the time of opposition 1781, and I computed (by means of the heliocentric motion, already determined for that opposition with sufficient accuracy) the place of the Planet for the beginning of the above mentioned interval. In like manner, I computed its place for two equal intervals of 369 *d.* 15 *b.* 49' 28", reckoned forward from the epoch. Thus I obtained four angles in the orbit, described in equal intervals of time. The differences of these angles showed the inequality of the Planet's angular motion. From this inequality alone, we are to determine the chief elements of its excentric orbit.

I IMMEDIATELY found, that these differences, strictly taken, had irregularities which are inconsistent with the most remarkable circumstances of the Planet's motions. It appeared, therefore, that the observations must be corrected, as far as is consistent with the probability of their inaccuracy. With respect

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to the observations of Dr MASKELYNE and Mr SLOP, made with instruments equal to any in Europe, this inaccuracy should not be supposed greater than $5''$. With respect to my own, I will allow it to amount to $10''$.

THE question is now, upon what good principle we may presume to correct the observations. When the Planet appears stationary, we have the best opportunity of ascertaining its distance from the Sun, by means of an imperfect knowledge of its angular motion, the earth's distance from the Sun affording a base most advantageously situated. Mr MINTO has communicated to me Mr SLOP's observations of the Planet when in this situation. On 1782, March, 6 *d.* 6 *b.* 14'. 56". M. T. Greenwich, the apparent longitude of the Planet was observed 2 *s.* 28° . 49'. 27". on the Ecliptic. The five observed oppositions give us the first and second differences of the heliocentric motion at those oppositions. By these means we obtain, by the usual methods of interpolation, the heliocentric place of the Planet at the time of the above observation, and this without an error amounting to $2''$. By comparing this with the geocentric place, we obtain the Planet's distance from the Sun = 18,9053. By making a similar interpolation for March 7 *d.* 6 *b.* 14'. 56", we obtain another heliocentric place of the Planet. The difference of these two places gives the diurnal heliocentric motion = $43''.4365$. But a Planet describing round the Sun a circle whose radius is 18,9053, will have its diurnal motion = $43''.1647$.

FROM this it is demonstrable, that the Planet's distance from the Sun is greater than half the parameter of its orbit; and that its true anomaly, or distance from its aphelion, is more than 90° *. On the other hand, we find, from the continual acceleration of its motion, that, at the opposition 1785, the Planet had

* For the angular velocity of a body in an ellipse, is to that of a body in a circle, at the same distance, in the subduplicate ratio of the half parameter to the distance.

had not yet arrived at its perihelion. Hence it is demonstrable, that the differences of the arches described in equal times should form a series of numbers continually decreasing, very slowly at first, but afterwards more rapidly.

UPON this principle, we may venture to correct the observations. In this correction there is still a choice; for we may make the decrease of the series either more or less rapid. The ellipses which arise from the extremes of the series formed upon this principle, will evidently be the limits which comprehend the principal elements of the eccentric motion; and, since we allow ourselves very little liberty in the correction, it is presumable, that these limits will not be very wide.

FROM the above observation of the Planet in its stationary point, we find that its angular velocity does not greatly exceed that of a Planet revolving in a circle; and a similar use being made of Mr MASKELYNE's first observations, will show, that the heliocentric motion of the Planet in April 1781 hardly exceeded the motion in a circle at the same distance. We may, therefore, presume that its true anomaly does not much exceed 90° . Therefore, the series of first differences, adapted to this situation, must decrease very slowly, whilst the second differences must increase also very slowly. This will appear by examining the tables of any of the Planets. I shall, therefore, begin by giving to the second differences a very small increase, and to the first differences a very small diminution. This will be done by a correction not exceeding $3''$ in any of the observations; and this must be allowed to be far within the limits of probability. The first observation has its longitude diminished $1''$; the second has its longitude increased $2\frac{1}{2}''$; the third has its longitude increased by the same quantity, and the fourth and fifth have their longitudes increased $3''$. The times corresponding to the above mentioned equal intervals, and the corresponding corrected longitudes, cleared from

the effects of aberration and mutation, and reduced to the orbit, and to the epoch of opposition 1783, are as follow :

		M. T. Green.	
		b. ' "	s. ° ' "
1781.	Dec. 21.	17. 20. 17	3. 00. 53. 50
1782.	Dec. 26.	09. 09. 45	3. 05. 21. 16,5
1783.	Dec. 31.	00. 59. 13	3. 09. 50. 37,5
1785.	Jan. 3.	16. 48. 41	3. 14. 21. 52
1786.	Jan. 8.	08. 38. 09	3. 18. 54. 58

THESE give us the following intercepted arches, with their first and second differences :

° ' "	' "	"
4. 27. 26,5	1. 54,5	"
4. 29. 21	1. 53,5	1
4. 31. 14,5	1. 51,5	2
4. 33. 06		

FROM these data, the elliptical orbit of the Planet is to be constructed. Various methods present themselves of doing this, depending on the equations between the mean and true anomaly. But I found that, unless the quantities involving the fourth power of the excentricity were introduced into the equation, I could not determine the place of the aphelion with tolerable accuracy. The equation in this form would be almost intractable. I therefore searched for a method which would be more simple, when applied to the present case, which has been rendered so particular, by the determination already obtained of the quarter of the orbit in which the Planet has been observed. The following method occurred to me, and is, indeed, as obvious as it is simple, while it is also susceptible of great accuracy.

LET ACP (fig. 1.) be the elliptical orbit of the Planet, P the perihelion, S the focus in which the Sun is placed, and O the centre;

centre ; and let A, B, C, D, E, be the places of the Planet in its successive oppositions to the Sun ; draw the chords AB, BC, CD, DE, AC, CE, and the radii vectores AS, BS, CS, DS, ES. We may suppose that the points χ and γ , where the chords AC, CE, are intersected by the radii vectores BS, DS, are in the middle of those chords. For, let us suppose that those chords are bisected in χ and γ by radii SB and SD, the rectilineal triangles ABS, BCS are equal, and the segments cut off by the chords AB, BC are very nearly equal ; these segments are very small in comparison with the triangles AB χ , B χ C, and these triangles are very small in comparison with the triangles A χ S, χ CS. Therefore, the elliptical sectors ABS, BCS, are very nearly equal, and B is very nearly the place of the Planet at the second opposition.

LET the angles ASB be = u , BSC = v , CSD = x , DSE = y .
ASC = w , CSE = z , A χ S = χ , and C γ S = γ .

Then, $AS : A\chi = \sin. \chi : \sin. u$,
and C χ , or A χ : CS = $\sin. v : \sin. \chi$.
therefore, $AS : CS = \sin. v : \sin. u$,
also, $ES : CS = \sin. x : \sin. y$.

THUS, we have obtained the ratio of the three distances AS, CS, ES, and we have the angles ASC, CSE, given by observation. This is all that is necessary for constructing the ellipse, by means of the 21st prop. of NEWTON's Principia, B. I. or of a theorem to be delivered afterwards.

THIS ellipse will be found to have its semitransverse axis about nineteen times the earth's distance from the Sun, and its excentricity about $\frac{1}{20}$ of its semitransverse axis, and the angle PSC about 73° . As it approaches very near to the form of the ellipse really described by the Planet, we may discover, by its means, the errors which have arisen from the supposition that the sectors ASB, BSC, are equal, when A χ is equal to χ B.

FOR

FOR this purpose, bisect AE in F, draw OF $\times$ and SFc ; make $\times$ c to Cc, as cS to cF ; draw C ϕ S, and draw OK parallel AE : It is evident that $\times$ c may be considered as a straight line parallel to EA ; the segments E $\times$ F, F $\times$ A, are equal, and the triangles EFS, FSA, are equal ; therefore the elliptical spaces E $\times$ FS, $\times$ FSA are equal ; but the triangles $\times$ cF, CcS are equal, their altitudes being reciprocally as their bases ; therefore, the elliptical sectors ACS, CSE, are equal, and C is the place of the Planet at the third opposition. Now, cF is nearly equal to the versed sine of cA, which is an arch of about 9° , and is therefore about $\frac{1}{80}$ of cS. $\times$ c is to cF as OK to KF ; and therefore $\times$ c is nearly $\frac{1}{20}$ of cF, or $\frac{1}{1600}$ of cS. Cc is $\frac{1}{80}$ of $\times$ c, or $\frac{1}{128000}$ of cS. Therefore the angle CSc does not exceed two seconds. If a similar construction be made for the points B and D, it will be found that the angles BSb, DSd, will not exceed $\frac{1}{8}$ of a second. For BS, CS, DS, are nearly equal, and bH and dG are nearly $\frac{1}{4}$ of cF ; therefore Bb and Dd are nearly $\frac{1}{16}$ of Cc.

HENCE it is evident, that this simple and obvious construction will give the elements of the orbit with all the accuracy that can be attained by any direct methods from our observations, because the errors of observation are much greater than this ; and if the observations are not equalised according to some probable principle, as has been attempted above, elements cannot be obtained which will be consistent with them all. The corrections which must be made for this equalisation are much greater than this error ; and, therefore, no direct methods can give more accurate elements.

THIS error, small as it is, may be very easily corrected, by computing its quantity in the ellipse already constructed. This computation

computation must be exceedingly near the truth, because the ellipse is very near the truth. But the trouble of this previous construction may be avoided by means of the following considerations: The triangles $\triangle Fc$, $\triangle Gd$, are nearly similar; and therefore, $cF : dG = AE^2 : CE^2$ nearly; therefore the triangle $\triangle cF : \triangle Gd = AE^4 : CE^4$ nearly; also, $Sc = Sd$ nearly; therefore, $Cc : Dd$ (or, $\phi F : \gamma G =$) $AE^4 : CE^4$ nearly; but AE is nearly double of CE ; therefore, $\phi F : \gamma G = 16 : 1$ nearly; also, $\phi F : \chi H = 16 : 1$ nearly.

Now, $CS : C\gamma = \sin. \gamma : \sin. x$,
 and $C\gamma : E\gamma = C\gamma : E\gamma$,
 and $E\gamma : ES = \sin. y : \sin. \gamma$,
 therefore, $CS : ES = C\gamma \times \sin. y : E\gamma \times \sin. x$.
 Let $CS : eS = \sin. y : \sin. x$,
 then, $ES : eS = E\gamma : C\gamma$,
 and $ES : Ee = E\gamma : C\gamma - E\gamma, = E\gamma : 2\gamma G$.

IN like manner, make $CS : aS = \sin. u : \sin. v$, and we shall have $AS : Aa = A\chi : 2\chi H$ nearly, $= E\gamma : 2\gamma G$ nearly, and $Ee : Aa = ES : AS$ nearly, and therefore Ee nearly equal to Aa .

Make $AS : So = \sin. z : \sin. w$,
 then, (because $SE : AS = E\phi \times \sin. w : A\phi \times \sin. z$)
 we have $SE : So = E\phi : A\phi$,
 and $SE : Eo = E\phi : A\phi - E\phi, = A\phi : 2\phi F$ nearly,
 or $SE : Eo = 2E\gamma : 32\gamma G, = E\gamma : 16\gamma G$ nearly.

Hence it follows that Eo is nearly equal to eight times Ee .

Lastly, Make $aS : S\epsilon = \sin. z : \sin. w$, then we shall have $aS : S\epsilon = AS : So$, and $Aa : \epsilon o = AS : SE$, and therefore ϵo nearly equal to Aa , or to Ee ; therefore $e\epsilon$ is nearly six times Ee .

HENCE

HENCE may be derived the following rule for approximating to the true ratios of AS and ES to CS :

$$\begin{aligned}\text{Make } CS : aS &= \sin. u : \sin. v, \\ CS : eS &= \sin. y : \sin. x, \\ eS : aS &= \sin. w : \sin. z, \\ aS : eS &= \sin. z : \sin. w.\end{aligned}$$

Then make $AS = aS + \frac{aa}{6}$, and $ES = eS - \frac{ee}{6}$. Then the points A, C, E, will be in the circumference of an ellipse, of which S is the focus, and O the centre, and having the sectors ASC, CSE, very nearly equal.

THE approximation will be much easier, and almost as accurate, if $\frac{1}{6}$ of the difference of the logarithms of aS and αS be added to the logarithm of aS, for the logarithm of AS, and $\frac{1}{6}$ of the difference of the logarithms of ϵS and eS be subtracted from the logarithm of eS for the logarithm of ES.

It may even be sufficient to add $\frac{1}{6}$ of the difference of the logarithms of eS and ϵS to the logarithms of aS, and to subtract it from the logarithm of eS.

THE following Theorem may be of use for constructing the ellipse, and, I believe, is new :

LET DAP be an ellipse, (fig. 2.) of which O is the centre, S the focus, and ap the directrix; from any three points A, C, E, draw lines Aa, Cc, Ee, perpendicular to the directrix; draw the radii AS, CS, ES; draw AK, CH, and ϵE , perpendicular to Aa, and AG, CF, perpendicular to ES, and Sp perpendicular to ap.

LET

LET AS be = a , CS = c , ES = e , the angle ASE = x , CSE = y , and ESP = z .

It is evident that EH : EK = ex : eA, = CS — ES : AS — ES, = $c - e : a - e$; also, SF = $c \cdot \cos y$, SG = $a \cdot \cos x$, CF = $c \cdot \sin y$, and AG = $a \cdot \sin x$; also, the angle FCH = GAK, = ESP, = z .

THEREFORE, FH = CF.tan, z , = $c \cdot \sin y \cdot \tan z$, and GK = $a \cdot \sin x \cdot \tan z$; therefore, EH = $e - c \cdot \cos y + c \cdot \sin y \cdot \tan z$, and EK = $e - a \cdot \cos x + a \cdot \sin x \cdot \tan z$; therefore, $c - e : a - e = e - c \cdot \cos y + c \cdot \sin y \cdot \tan z : e - a \cdot \cos x + a \cdot \sin x \cdot \tan z$, and $(c - e) \cdot (e - a \cdot \cos x) + (c - e) \cdot a \cdot \sin x \cdot \tan z = (a - e) \cdot (e - c \cdot \cos y) + (a - e) \cdot c \cdot \sin y \cdot \tan z$. This gives,

$$\tan, z = \frac{(c - e) \cdot (e - a \cdot \cos x) - (a - e) \cdot (e - c \cdot \cos y)}{c \cdot (a - e) \cdot \sin y - a \cdot (c - e) \cdot \sin x}$$

Or, more conveniently for logarithms,

$$\tan, z = \frac{c \cdot (a - e) \cdot \cos y - a \cdot (c - e) \cdot \cos x - e \cdot (a - c)}{c \cdot (a - e) \cdot \sin y - a \cdot (c - e) \cdot \sin x}$$

Then, by the common theorems, we have the excentricity $\epsilon = \frac{a - e}{e \cdot \cos z - a \cdot \cos (x + z)}$, the mean distance being = 1. The aphelion and perihelion distances are $1 + \epsilon$ and $1 - \epsilon$. By their means, we obtain the mean anomalies corresponding to the true anomalies OSA and OSE. The difference of the mean anomalies is to 360° , as the time between the appulses of the Planet to the points A and E to the time of a fyderal revolution. The square of a fyderal year is to the square of the time of this revolution, as 1 to the cube of the Planet's mean distance from the Sun.

This process gives us the following elements :

Mean Distance,	-	-	19,08247
Excentricity,	-	-	0,9006
Periodic Time,	-	-	83,359 Years.
	S f		Mean

Mean Anomaly at E,		s	°	'	"
Longitude of the Aphelion, } for the Epoch		4.	00.	32.	51
Longitude of the Node, } 1783, Dec. 31.		11.	23.	09.	51
Inclination of the Orbit, -		2.	12.	46.	14
		00.	00.	46.	25

THESE elements agree with all the observations made since Mr HERSCHEL's discovery of the Planet, with abundant accuracy, the differences being as often, and as much, in defect as in excess. When I compared them with MAYER's observation of the Star, No. 964. I found the calculated place of the Planet only 3'. 52" to the westward of the Star, and 1" to the northward. As these elements seem to be formed on good principles, I cannot help being of opinion, that that Star was the Planet now observed. If, in forming the elements, I had supposed that the second differences of the arches were constant, (a supposition quite allowable,) I should have obtained elements almost precisely the same with those which I formerly deduced from the supposition that the Star, No. 964. of MAYER's Catalogue, was the Planet. This assumption would not have occasioned an alteration of one second in any of the places above used.

ALTHOUGH it now appeared unnecessary to make any farther trial, I made another correction of the observations, so as to produce a series of second differences, which should decrease as rapidly as was consistent with the probable inaccuracy of the observations. This gave me the following elements:

Mean Distance,	-	-	19,18254
Excentricity,	-	-	0,88461
			s. ° ' "
Mean Longitude,	{	1786 Jan. 1.	3. 23. 17. 03
Long. of Aphelion,		M. T. Green.	11. 17. 32. 54
			y. d. h. '
Periodic Time,			84. 06. 04. 48

THESE elements also agreed very well with the observations since HERSCHEL's discovery; as also with MAYER's observations: But if these elements be compared with the observation of the station

station in March 1782, they produce an angular motion, which differs considerably from what appears by interpolation, showing that the mean distance is considerably too great.

It results from this investigation, that the elements of the orbit are contained between these extremes, and are probably much nearer to the first set. A considerable time must elapse before they can be determined with accuracy, from observations made since March 1781. But the probability that MAYER observed the Planet is so great, that I am decidedly of opinion that it is the same with No. 964. of his catalogue. If his be granted, we can obtain the elements with all the accuracy that is attained in the other Planets: For the place of MAYER's Star is within six degrees of the Aphelion, as determined by the first set of elements, and all the effects of its excentricity are nearly accumulated in 1781; and are therefore most easily deduced from the observations. I shall therefore subjoin another set of elements accommodated to this supposition; they were formed by me about two years ago in the usual way, by repeated trial, till the result should agree with MAYER's observations, and with all the others which I had then collected. I have not found any reason since that time to make any change, unless perhaps the inclination of the orbit may be increased about 10".

Mean Distance,	-	-	19,0858
Excentricity,	-	-	0,90737
Mean Longitude, 1786 Jan. 1. Noon. M. T.	s.	'	"
Green.			3. 23. 41. 13
Longitude of the Aphelion,	-		11. 23. 10. 38
Longitude of the Node,	-		2. 12. 48. 45
Inclination of the Orbit,	-		00. 00. 46. 26
Periodic Time in Days,	30456.	01. 40. 48	
Mean diurnal Motion,		42",551	

I MAY just observe in this place, that if I were disposed, with some astronomers, to admit that the Star, No. 34. Tauri of the Britannic Catalogue, is the new Planet, the elements formed on

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the supposition of the most rapid decrease of the second differences will agree very well with FLAMSTEAD's observation of that Star on December 13. 1690, being only 40", or perhaps only 12", to the westward of it. But the latitude differs more than two minutes from FLAMSTEAD's latitude, which is rightly deduced from the Zenith distance. This is too great an error for him to commit in the observation, and we should therefore reject the supposition on this account alone. But there are stronger reasons for rejecting it, arising from the disagreement of those elements with the observations made on the stations of the Planet in October 1781, and March and October 1782, which give us a very near approximation to its distance from the Sun. When compared with observations of the Planet near its stationary points in the Spring, they give the geocentric longitude considerably too great, while they give it too small for the similar observations in Autumn.

THE appearance of this Planet has served to exercise the ingenuity of mathematicians, by a problem considerably different from that afforded by the motions of comets in very excentric orbits; and, by this means, has favoured the public with many improvements in analytical knowledge. My professional duty has made me confine myself chiefly to the search of such methods as might be very intelligible to persons possessed of small degrees of mathematical knowledge. The method now exhibited has this advantage in an eminent degree; and therefore, although it will not engage the attention of skilful mathematicians, I hope it will be useful, because it may incite beginners to a zealous prosecution of this noble study, by showing them some of its most pleasing gratifications. I may add, that the method now exhibited is one of the most likely to give us an accurate knowledge of the Planet's motion. Another period of four years will enable us to apply it to arches of double extent, which will diminish the errors arising from the unavoidable inaccuracy of observations to one fourth of their present quantity, and a comparison of the new elements with those now
given,

given, will enable us to diminish them as much again. When it is considered, that in those elements no attention has been paid to the gravitation of the Planet to the other fix, it will still more clearly appear how abundantly accurate they are for the purposes of astronomical computation.

I TOOK another method of obtaining elements, by means of the ratio of three distances from the Sun; namely, by interpolating heliocentric places of the Planet, for the times of its vicinity to its stations, and comparing these with its geocentric places. It is easy to see, that this method also is susceptible of great accuracy, after having observed five oppositions, which give us second and third differences of the heliocentric places, and therefore afford a proper application of the methods of interpolation. Elements deduced in this way, almost perfectly coincided with the above. I also obtained, in January 1784, a set of elements very nearly the same, by means of the three oppositions which had then been observed, and by the help of a theorem which I make use of in my elements of physical astronomy, *viz.* That the velocity of a body, in any point of the path which it describes by the action of a centripetal force, is that which it would acquire if uniformly impelled by the centripetal force along $\frac{1}{4}$ of that chord of the osculating circle which passes through the centre of forces.

I SHALL here subjoin tables for computing the motion of this Planet.

TABLE I. contains the Radical Mean Longitudes of the Planet, Aphelion, and Node; for the Mean Time of noon at Greenwich, at the beginning of the Astronomical Year, that is, for the Mean Noon of the 31st of December immediately preceding. It also contains the Mean Sydereal Motions of the Planet for months, days, and hours, and the precession of the Equinoxes at the beginning of each month. The sydereal motions are chosen in preference to the tropical, because the motions of the aphelion and node are not yet known. One application of the precession of the equinoctial points, is therefore sufficient.

TABLE

TABLE II. contains the Elliptic Equation of the Planet. The argument is the Mean Anomaly, or the Mean Longitude of the Planet—the Longitude of the Aphelion.

TABLE III. contains the Logarithm of the Planet's distance from the Sun, the Earth's mean distance being 1. The argument is the Mean Anomaly of the Planet.

TABLE IV. contains the Heliocentric Latitude of the Planet, the Reduction to the Ecliptic, and the Reduction of the Logarithm of the distance from the Sun. The argument is the Orbital Longitude of the Planet—the Longitude of the Node.

TABLE V. contains the Geocentric Aberration of the Planet, for reducing its true to the apparent place. The argument is the Elongation of the Planet from the Sun.

E X A M P L E.

REQUIRED the heliocentric place of the Planet for 1787, January 13 *d.* 04 *b.* 56' 00" M. T. Greenwich.

	s. ° ' "		s. ° ' "		s. ° ' "
1787. M. Lon. Plan.	3. 28. 00. 12,5	Lon. Aphel.	11. 23. 11. 28	Lon. Nod.	2. 12. 49. 35
Jan. } M. Mot.	0. 00. 00. 00		3. 28. 09. 35		3. 23. 32. 35
13- } M. Mot.	9. 13,2	M. An.	4. 04. 58. 07	Arg. Lat.	1. 10. 43. 00
4 } M. Mot.	7,1			Hel. Lat. N.	30. 15
56' } M. Mot.	1,7	Log. dist. ☉	1.2694179		
		Red. Log.	168		
Eq. Orbit,	3. 28. 09. 34,5	Log. curt. dist.	1. 2694011		
	4. 36. 59,3				
Prec.—Red.	3. 23. 32. 35,2				
	7,4				
Plan. for M. Eq ^x .	3. 23. 32. 27,8				

It will be remarked, that the deviations from observations made near the vernal stations are in defect, while those near the autumnal stations are in excess. Hence it may be presumed, that the mean distance and periodic time are somewhat too small, and the aphelion too far advanced on the ecliptic. I did not remark this till after I had computed the tables; and it is a tedious task to make the computation a-new. I have published them, not in the persuasion that they are perfect, but because none have as yet been published in Britain, and I have seen only those of DE LA PLACE and ORIANI, both of which are less consistent with observations than mine.

TABLE I.

RADICAL MEAN PLACES, AND MOTIONS.

	M. Lon. Plan.	Lon. Aphel.	Lon. Node.	D.	M. Mot.	H.	Mot.
	s o ' "	s o ' "	s o ' "		' "		"
1756	11. 13. 43. 43,1	11. 22. 25. 48	2. 12. 23. 35	1	0. 42,5	1	1,8
1781	3. 02. 01. 16,5	10. 23. 06. 26	2. 12. 44. 34	2	1. 25,1	2	3,6
1782	3. 06. 20. 59,0	11. 23. 07. 16	2. 12. 45. 24	3	2. 07,7	3	5,3
1783	3. 10. 40. 41,0	11. 23. 08. 07	2. 12. 46. 14	4	2. 50,2	4	7,1
1784	3. 15. 00. 23,0	11. 23. 08. 57	2. 12. 47. 05	5	3. 32,7	5	8,9
1785	3. 19. 20. 48,0	11. 23. 09. 48	2. 12. 47. 55	6	4. 15,3	6	10,6
1786	3. 23. 40. 30,5	11. 23. 10. 38	2. 12. 48. 45	7	4. 57,9	7	12,4
1787	3. 28. 00. 12,5	11. 23. 11. 28	2. 12. 49. 35	8	5. 40,5	8	14,2
1788	4. 02. 19. 54,7	11. 23. 12. 19	2. 12. 50. 26	9	6. 23,0	9	16,0
1789	4. 06. 40. 19,5	11. 23. 13. 09	2. 12. 51. 16	10	7. 05,6	10	17,7
1790	4. 11. 00. 01,7	11. 23. 13. 59	2. 12. 52. 06	11	7. 48,1	11	19,5
1791	4. 15. 19. 23,9	11. 23. 14. 50	2. 12. 52. 57	12	8. 30,7	12	21,3
1792	4. 19. 39. 06,1	11. 23. 15. 40	2. 12. 53. 47	13	9. 13,2	13	23,1
1793	4. 23. 29. 30,9	11. 23. 16. 31	2. 12. 54. 32	14	9. 55,8	14	24,8
1794	4. 28. 19. 13,1	11. 32. 17. 21	2. 12. 55. 28	15	10. 38,3	15	26,6
1795	5. 02. 38. 55,3	11. 23. 18. 12	2. 12. 56. 18	16	11. 20,9	16	28,4
				17	12. 03,4	17	30,1
				18	12. 46,0	18	31,9
				19	13. 28,5	19	33,7
				20	14. 11,1	20	35,5
				21	14. 53,6	21	37,2
				22	15. 36,2	22	39,0
				23	16. 18,7	23	40,8
				24	17. 01,3	24	42,5
				25	17. 43,8	25	
				26	18. 26,4	26	
				27	19. 08,9	27	
				28	19. 51,5	28	
				29	20. 34,0	29	
				30	21. 16,6	30	
				31	21. 59,1	31	
Month.	M. Motion.	P. Eq.	N. B. In taking out the M. Mot. for any day in a leap year, after the 29th of February, reckon one day more.				
	s ' "	"					
Jan. o	00. 00. 00,0	0,0					
Feb. o	00. 21. 59,1	4,3					
Mar. o	00. 41. 50,6	8,3					
Apr. o	1. 03. 49,8	12,5					
May, o	1. 25. 06,4	16,7					
June, o	1. 47. 05,5	20,9					
July, o	2. 08. 22,1	25,1					
Aug. o	2. 30. 21,3	29,3					
Sept. o	2. 52. 20,4	33,6					
Oct. o	3. 13. 37,0	37,8					
Nov. o	3. 35. 36,1	42,0					
Dec. o	3. 56. 52,8	46,1					

TAB. II. ELLIPTICAL EQUATION.

Arg. M. An.

	O		I.		II.		
	—	Diff.	—	Diff.	—	Diff.	
o	o ' "	' "	o ' "	' "	o ' "	' "	o
0	0. 00. 00,0		2. 3 5 22,4		4. 34. 36,5		30
		5. 23,0		4. 44,7		2. 57,7	
1	0. 05. 23,0	5. 23,0	2. 40. 07,1	4. 42,5	4. 37. 34,2	2. 53,2	29
2	0. 10. 46,0	5. 22,8	2. 44. 49,6	4. 39,9	4. 40. 27,4	2. 48,4	28
3	0. 16. 08,8	5. 22,5	2. 49. 29,5	4. 37,2	4. 43. 15,8	2. 43,7	27
4	0. 21. 31,3	5. 22,2	2. 54. 06,7	4. 34,5	4. 45. 59,5	2. 38,9	26
5	0. 26. 53,5	5. 21,9	2. 58. 41,2	4. 31,7	4. 48. 38,4	2. 34,2	25
6	0. 32. 15,4	5. 21,3	3. 03. 12,9	4. 28,8	4. 51. 12,6	2. 29,1	24
7	0. 37. 36,7	5. 20,7	3. 07. 41,7	4. 25,8	4. 53. 41,7	2. 24,0	23
8	0. 42. 57,4	5. 20,1	3. 12. 07,5	4. 22,8	4. 56. 05,7	2. 19,2	22
9	0. 48. 17,5	5. 19,3	3. 16. 30,3	4. 19,6	4. 58. 24,9	2. 14,1	21
10	0. 53. 36,8	5. 18,5	3. 20. 49,9	4. 16,4	5. 00. 39,0	2. 08,9	20
11	0. 58. 55,3	5. 17,6	3. 25. 06,3	4. 13,2	5. 02. 47,9	2. 03,8	19
12	1. 04. 12,9	5. 16,6	3. 29. 19,5	4. 09,8	5. 04. 51,7	1. 58,5	18
13	1. 09. 29,5	5. 15,5	3. 33. 29,3	4. 06,4	5. 06. 50,2	1. 53,2	17
14	1. 14. 45,0	5. 14,4	3. 37. 35,7	4. 03,0	5. 08. 43,4	1. 47,9	16
15	1. 19. 59,4	5. 13,2	3. 41. 38,7	3. 59,3	5. 10. 31,3	1. 42,6	15
16	1. 25. 12,6	5. 11,8	3. 45. 38,0	3. 55,8	5. 12. 13,9	1. 37,1	14
17	1. 30. 24,4	5. 10,5	3. 49. 33,8	3. 52,0	5. 13. 51,0	1. 31,7	13
18	1. 35. 34,9	5. 09,0	3. 53. 25,8	3. 48,3	5. 15. 22,7	1. 26,1	12
19	1. 40. 43,9	5. 07,4	3. 57. 14,1	3. 44,3	5. 16. 48,8	1. 20,7	11
20	1. 45. 51,3	5. 05,7	4. 00. 58,4	3. 40,6	5. 18. 09,5	1. 15,0	10
21	1. 50. 57,0	5. 04,1	4. 04. 39,0	3. 36,5	5. 19. 24,5	1. 09,4	9
22	1. 56. 01,1	5. 02,3	4. 08. 15,5	3. 32,5	5. 20. 33,9	1. 03,8	8
23	2. 01. 03,4	5. 00,3	4. 11. 48,0	3. 28,4	5. 21. 37,7	0. 58,0	7
24	2. 06. 03,7	4. 58,5	4. 15. 16,4	3. 24,2	5. 22. 35,7	0. 52,3	6
25	2. 11. 02,2	4. 56,3	4. 18. 40,6	3. 19,9	5. 23. 28,0	0. 46,6	5
26	2. 15. 58,5	4. 54,3	4. 22. 00,5	3. 15,5	5. 24. 14,6	0. 40,7	4
27	2. 20. 52,8	4. 52,1	4. 25. 16,0	3. 11,2	5. 24. 55,3	0. 34,9	3
28	2. 25. 44,9	4. 49,9	4. 28. 27,2	3. 07,0	5. 25. 30,2	0. 29,1	2
29	2. 30. 34,8	4. 47,6	4. 31. 34,2	3. 02,3	5. 25. 59,3	0. 23,1	1
30	2. 35. 22,4		4. 34. 36,5		5. 26. 22,4		0
	+		+		+		
	XI.		X.		IX.		

TAB. II. ELLIPTICAL EQUATION.

Arg. M. An.

	III.			IV.			V.		
	—	Diff.		—	Diff.		—	Diff.	
0	0' "	" "	0' "	" "	0' "	" "	0' "	" "	0
0	5. 26. 22,4		4. 51. 23,4		2. 52. 12,4		5. 08,1		30
1	5. 26. 39,8	0. 17,4	4. 48. 40,6	2. 42,8	2. 47. 04,3	5. 12,0			29
2	5. 26. 51,2	0. 11,4	4. 45. 52,2	2. 48,4	2. 41. 52,3	5. 15,3			28
3	5. 26. 56,6	0. 05,4	4. 42. 58,4	2. 53,8	2. 36. 37,0	5. 18,7			27
4	5. 26. 56,0	0. 00,6	4. 39. 58,3	3. 00,1	2. 31. 18,3	5. 21,9			26
5	5. 26. 48,4	0. 08,6	4. 36. 53,3	3. 05,0	2. 25. 56,4	5. 25,1			25
6	5. 26. 36,9	0. 11,5	4. 33. 42,4	3. 10,9	2. 20. 31,3	5. 28,1			24
7	5. 26. 18,3	0. 18,6	4. 30. 26,0	3. 16,4	2. 15. 03,2	5. 31,0			23
8	5. 25. 53,7	0. 24,6	4. 27. 04,3	3. 21,7	2. 09. 32,2	5. 33,8			22
9	5. 25. 23,0	0. 30,7	4. 23. 37,0	3. 27,3	2. 03. 58,4	5. 36,5			21
10	5. 24. 46,2	0. 36,8	4. 20. 04,5	3. 32,5	1. 58. 21,9	5. 39,0			20
11	5. 24. 03,5	0. 42,7	4. 16. 26,5	3. 38,0	1. 52. 42,9	5. 41,5			19
12	5. 23. 14,6	0. 48,9	4. 12. 43,3	3. 43,2	1. 47. 01,4	5. 43,7			18
13	5. 22. 19,4	0. 55,2	4. 08. 55,0	3. 48,3	1. 41. 17,7	5. 46,0			17
14	5. 21. 18,7	1. 00,7	4. 05. 01,6	3. 53,4	1. 35. 31,7	5. 47,9			16
15	5. 20. 11,5	1. 07,2	4. 01. 03,0	3. 58,6	1. 29. 43,6	5. 50,0			15
16	5. 18. 58,4	1. 13,1	3. 56. 59,6	4. 03,4	1. 23. 53,6	5. 51,9			14
17	5. 17. 39,3	1. 19,1	3. 52. 51,2	4. 08,4	1. 18. 01,7	5. 53,5			13
18	5. 16. 14,0	1. 25,3	3. 48. 38,0	4. 13,2	1. 12. 08,2	5. 55,1			12
19	5. 14. 42,5	1. 31,5	3. 44. 20,0	4. 18,0	1. 06. 13,1	5. 56,6			11
20	5. 13. 05,2	1. 37,3	3. 39. 57,3	4. 22,7	1. 00. 16,5	5. 57,9			10
21	5. 11. 21,9	1. 43,3	3. 35. 30,1	4. 27,2	0. 54. 18,6	5. 59,0			9
22	5. 09. 32,3	1. 49,6	3. 30. 58,4	4. 31,7	0. 48. 19,6	6. 00,2			8
23	5. 07. 37,0	1. 55,3	3. 26. 22,2	4. 36,2	0. 42. 19,4	6. 01,0			7
24	5. 05. 35,6	2. 01,4	3. 21. 41,6	4. 40,6	0. 36. 18,4	6. 01,9			6
25	5. 03. 28,2	2. 07,4	3. 16. 56,8	4. 44,8	0. 30. 16,5	6. 02,5			5
26	5. 01. 15,3	2. 12,9	3. 12. 07,9	4. 48,9	0. 24. 14,0	6. 03,0			4
27	4. 58. 55,8	2. 19,5	3. 07. 14,9	4. 53,0	0. 18. 11,0	6. 03,5			3
28	4. 56. 31,0	2. 24,8	3. 02. 17,9	4. 57,0	0. 12. 07,5	6. 03,7			2
29	4. 54. 00,0	2. 31,0	2. 57. 17,1	5. 00,8	0. 06. 03,8	6. 03,8			1
30	4. 51. 23,4	2. 36,6	2. 52. 12,4	5. 04,7	0. 00. 00,0				0
	+		+		+				
	VIII.		VII.		VI.				

T t

T A B. III. Logarithm of the PLANET's Distance from the SUN.

Arg. M. An.

	O		I.		II.		
°	Logar.	Diff.	Logar.	Diff.	Logar.	Diff.	°
0	1.3008817		1.2984548		1.2916063		30
1	1.3008790	27	1.2982929	1619	1.2913149	2914	29
2	1.3008708	82	1.2981260	1669	1.2910200	2949	28
3	1.3008571	137	1.2979542	1718	1.2907217	2983	27
4	1.3008379	192	1.2977775	1767	1.2904202	3015	26
5	1.3008133	246	1.2975959	1816	1.2901155	3047	25
6	1.3007833	300	1.2974094	1865	1.2898077	3078	24
7	1.3007478	355	1.2972182	1912	1.2894968	3109	23
8	1.3007068	410	1.2970224	1959	1.2891828	3140	22
9	1.3006604	464	1.2968218	2006	1.2888659	3169	21
10	1.3006085	519	1.2966165	2053	1.2885462	3197	20
11	1.3005512	573	1.2964065	2100	1.2882237	3225	19
12	1.3004886	626	1.2961920	2145	1.2878985	3252	18
13	1.3004206	680	1.2959730	2190	1.2875708	3277	17
14	1.3003472	734	1.2957495	2235	1.2872406	3302	16
15	1.3002684	788	1.2955216	2279	1.2869080	3326	15
16	1.3001842	842	1.2952892	2324	1.2865730	3350	14
17	1.3000947	895	1.2950525	2367	1.2862358	3372	13
18	1.2999999	948	2.2948116	2409	1.2858964	3394	12
19	1.2998998	1001	1.2945664	2452	1.2855550	3414	11
20	1.2997945	1053	1.2943170	2494	1.2852116	3434	10
21	1.2996839	1106	1.2940635	2535	1.2848662	3454	9
22	1.2995679	1160	1.2938060	2575	1.2845190	3472	8
23	1.2994467	1212	1.2935445	2615	1.2841702	3488	7
24	1.2993203	1264	1.2932790	2655	1.2838198	3504	6
25	1.2991888	1315	1.2930095	2695	1.2834680	3518	5
26	1.2990522	1366	1.2927362	2733	1.2831148	3532	4
27	1.2989105	1417	1.2924592	2770	1.2827603	3545	3
28	1.2987636	1469	1.2921786	2806	1.2824045	3558	2
29	1.2986117	1519	1.2918943	2843	1.2820476	3569	1
30	1.2984548	1569	1.2916063	2879	1.2816896	3580	0
	Logar.	Diff.	Logar.	Diff.	Logar.	Diff.	
	XI.		X.		IX.		

T A B. III. Logarithm of the PLANET'S Distance from the SUN.

Arg. M. An.

	III.		IV.		V.		
9	Logar.	Diff.	Logar.	Diff.	Logar.	Diff.	°
0	1.2816896		1.2710423		1.2627235		30
1	1.2813308	3588	1.2707098	3325	1.2625225	2010	29
2	1.2809712	3596	1.2703799	3299	1.2623274	1951	28
3	1.2806110	3602	1.2700528	3271	1.2621382	1892	27
4	1.2802503	3607	1.2697288	3240	1.2619552	1830	26
5	1.2798891	3612	1.2694078	3210	1.2617785	1767	25
6	1.2795275	3616	1.2690899	3179	1.2616080	1705	24
7	1.2791656	3619	1.2687754	3145	1.2614439	1641	23
8	1.2788036	3620	1.2684644	3110	1.2612863	1576	22
9	1.2784416	3620	1.2681570	3074	1.2611352	1511	21
10	1.2780797	3619	1.2678533	3037	1.2609906	1446	20
11	1.2777181	3616	1.2675534	2999	1.2608526	1380	19
12	1.2773567	3614	1.2672574	2960	1.2607214	1312	18
13	1.2769958	3609	1.2669653	2921	1.2605969	1245	17
14	1.2766354	3604	1.2666773	2880	1.2604793	1176	16
15	1.2762757	3597	1.2663936	2837	1.2603686	1107	15
16	1.2759168	3589	1.2661143	2793	1.2602647	1039	14
17	1.2755589	3579	1.2658396	2747	1.2601677	970	13
18	1.2752020	3569	1.2655695	2701	1.2600777	900	12
19	1.2748461	3559	1.2653041	2654	1.2599948	829	11
20	1.2744915	3546	1.2650434	2607	1.2599190	758	10
21	1.2741384	3531	1.2647875	2559	1.2598504	688	9
22	1.2737868	3516	1.2645367	2508	1.2597888	616	8
23	1.2734367	3501	1.2642911	2456	1.2597345	543	7
24	1.2730884	3483	1.2640507	2404	1.2596874	471	6
25	1.2727420	3464	1.2638157	2350	1.2596475	399	5
26	1.2723976	3444	1.2635861	2296	1.2596148	327	4
27	1.2720553	3423	1.2633620	2241	1.2595893	255	3
28	1.2717152	3401	1.2631434	2186	1.2595711	182	2
29	1.2713775	3377	1.2629305	2129	1.2595601	110	1
30	1.2710423	3352	1.2627235	2070	1.2595564	37	0
	Logar.	Diff.	Logar.	Diff.	Logar.	Diff.	
	VIII.		VII.		VI.		

TABLE IV.

	o. N. VI. S.			I. N. VII. S.			II. N. VIII. S.			
	Lat.	Red.	R. log	Lat.	Red.	R. log	Lat.	Red.	R. log	
0	"	"	"	"	"	"	"	"	"	0
0	00.00	0	0	23.12	8	99	40.12	8	297	30
1	00.49	0	0	23.54	8	105	40.36	8	303	29
2	1.37	1	1	24.36	8	111	40.59	8	309	28
3	2.26	1	1	25.17	9	117	41.21	8	314	27
4	3.14	1	2	25.57	9	124	41.43	7	320	26
5	4.03	2	3	26.37	9	130	42.04	7	325	25
6	4.51	2	4	27.17	9	137	42.24	7	330	24
7	5.39	2	6	27.56	9	143	42.43	7	335	23
8	6.28	3	8	28.35	9	150	43.02	7	340	22
9	7.16	3	10	29.13	9	157	43.20	6	345	21
10	8.04	3	12	29.50	9	164	43.37	6	349	20
11	8.51	4	14	30.27	9	170	43.53	6	354	19
12	9.39	4	17	31.03	9	177	44.08	6	358	18
13	10.26	4	20	31.29	9	184	44.23	5	362	17
14	11.14	4	23	32.14	9	191	44.37	5	366	16
15	12.01	5	26	32.49	9	198	44.50	5	369	15
16	12.48	5	30	33.23	9	205	45.02	4	372	14
17	13.34	5	33	33.57	9	211	45.13	4	376	13
18	14.21	6	38	34.30	9	219	45.24	4	379	12
19	15.07	6	42	35.02	9	226	45.34	4	381	11
20	15.53	6	46	35.33	9	233	45.43	3	384	10
21	16.38	6	51	36.04	9	239	45.51	3	386	9
22	17.23	7	55	36.34	9	246	45.58	3	389	8
23	18.08	7	61	37.04	9	253	46.04	2	390	7
24	18.53	7	65	37.33	9	259	46.10	2	392	6
25	19.37	7	71	38.01	9	265	46.15	2	393	5
26	20.21	7	76	38.29	9	272	46.18	1	394	4
27	21.04	8	82	38.56	9	278	46.21	1	394	3
28	21.47	8	88	39.22	8	285	46.23	1	394	2
29	22.30	8	93	39.47	8	291	46.25	0	395	1
30	23.12	8	99	40.12	8	297	46.26	0	396	0
	XI. S. V. N.	+	-	X. S. IV. N.	+	-	IX. S. III. N.	+	-	

TAB. V.

	Elong.	Ab.
		"
O.	00	-24
	10	-23
	20	-21
I.	00	-19
	10	-17
	10	-15
II.	20	-13
	10	-10
	20	-7
III.	00	-3
	10	-0
	20	+3
IV.	00	+6
	01	+9
	02	+11
V.	00	+12
	10	+14
	20	+15
VI.	00	+16

XII. ABSTRACT of a REGISTER of the WEATHER, kept at HAWKHILL, near Edinburgh; containing Observations of the Thermometer, the Quantity of Rain and Evaporation, from 1771 to 1776 inclusive.

[Communicated by Mr MACGOWAN.]

THIS Abstract contains the medium heat for the half of each month, and is a continuation of that inserted in the last Volume of the *Physical and Literary Essays*.

HAWKHILL is situated $1\frac{1}{2}$ mile N. E. of Edinburgh.

THE Observations of the Thermometer were made every day at 8 o'clock A. M.

Months.		1771.			1772.		
1st and 2d halves.		Ther.	Rain.	Evapor.	Ther.	Rain.	Evapor.
		Deg.	Inch.	Inch.	Deg.	Inch.	Inch.
January,	1	31.80			32.40		
	2	34.56	1.043	0.343	30.56	2.681	0.000
February,	1	35.00			29.42		
	2	38.28	1.165	3.395	32.46	1.385	0.000
March,	1	35.80			36.00		
	2	36.00	0.538	0.958	38.00	1.685	0.805
April,	1	38.46			43.20		
	2	44.86	0.440	2.540	42.60	1.299	2.549
May,	1	47.66			48.93		
	2	53.12	1.385	3.335	49.31	2.024	3.854
June,	1	54.46			55.93		
	2	56.93	0.482	4.382	58.40	2.997	4.367
July,	1	59.06			60.26		
	2	57.93	1.848	4.248	57.06	3.688	4.188
August,	1	57.26			58.00		
	2	56.00	3.229	3.429	56.75	2.710	3.018
September,	1	52.46			53.60		
	2	50.93	1.742	1.942	49.46	3.261	
October,	1	46.86			50.73		3.294
	2	46.75	5.591	1.491	46.88	3.513	
November,	1	41.46			44.13		
	2	42.26	3.765	0.815	39.33	5.659	0.749
December,	1	43.53			42.00		
	2	39.12	0.966	0.666	37.31	1.282	0.572
Sums,			22.194	24.544		32.184	23.558
Means,		45.85			45.53		

Months.		1773.			1774.		
1st and 2d halves.		Therm.	Rain.	Evapor.	Therm.	Rain.	Evapor.
		Deg.	Inch.	Inch.	Deg.	Inch.	Inch.
January,	1	39.06			28.46		
	2	38.06	3.526	1.436	29.75	2.775	
February,	1	32.14			34.14		3.699
	2	38.00	1.154	0.504	38.28	2.024	
March,	1	40.46			34.06		
	2	43.66	1.225	1.695	40.18	0.859	1.759
April,	1	42.40			43.13		
	2	48.80	3.530	3.530	43.13	1.737	3.387
May,	1	44.33			46.73		
	2	52.81	1.827	3.477	46.50	3.490	3.540
June,	1	54.13			54.80		
	2	56.26	0.873	3.673	55.40	3.868	3.268
July,	1	56.33			57.40		
	2	59.06	1.405	6.805	57.50	1.513	4.463
August,	1	60.40			58.13		
	2	56.12	1.283	3.583	56.37	4.818	3.168
September,	1	53.26			52.40		
	2	49.33	3.680		51.00	2.925	2.525
October,	1	47.20		5.385	51.06		
	2	44.87	2.955		45.50	1.305	2.105
November,	1	41.53			40.63		
	2	34.93	3.369	0.119	35.50	2.179	2.179
December,	1	35.60			37.40		
	2	37.25	3.915	1.715	37.25	2.692	0.000
Sums,			28.842	31.922		30.185	30.093
Means,		46.08			44.86		

Months.

Months.		1775.			1776.		
1st and 2d halves.		Therm.	Rain.	Evapor.	Therm.	Rain.	
		Deg.	Inch.	Inch.	Deg.	Inch.	
January,	1	39.10			33.33		Medium of heat for the six preceding years, deg. 45.06.
	2	36.50	4.591	2.040	25.16	3.262	
February,	1	37.64			36.32		
	2	40.50	3.014	2.214	35.00	2.355	
March,	1	39.80			37.60		
	2	40.31	1.586	2.836	44.12	1.465	
April,	1	44.83			43.60		
	2	48.83	0.578	3.928	48.20	1.213	
May,	1	52.60			47.36		
	2	52.88	1.422	5.272	51.22	0.626	
June,	1	55.66			55.00		
	2	57.53	1.209	3.309	56.00	2.367	
July,	1	58.20			58.16		
	2	60.06	5.806	3.556	60.56	3.075	
August,	1	59.10			58.60		
	2	56.21	2.364	2.514	54.86	2.410	
September,	1	53.20			55.00		
	2	53.33	3.820	1.920	48.60	2.755	
October,	1	48.86			48.60		
	2	41.75	5.309	2.109	45.38	1.735	
November,	1	38.00			45.80		
	2	37.93	3.615	0.165	36.13	2.750	
December,	1	41.16			42.54		
	2	36.00	0.760	0.660	33.00	2.080	
Sums,			34.298	30.754		26.093	
Means,		47.08			45.84		

Greatest

Greatest Degrees of Cold and Heat, observed at Hawkhill, from 1766 to 1776 inclusive.

				Fahr. Therm.
1767.	January 17.	at 8½ h. P. M.	- -	17.50
1768.	January 3.	at 10 h. P. M.	- -	17.00
	17.	at 8 h. A. M.	- -	17.00
1772.	February 1.	at 7¼ h. A. M.	-	12.00
N. B. At Selkirk the thermometer, same morning, continued from 6 h. to 8 h. A. M.				1.50
1774.	January 12.	at 7 h. A. M.	- -	17.00
N. B. Selkirk at 8 h. A. M.				12.00
And the preceding night at 12 h.				8.00
1776.	January 31.	at 8 h. A. M.	-	14.00
Same h. at Observatory, Hawkhill,				11.00
At Botanic garden, at 6 h. A. M. said day,				5.00
1770.	August 5.	at 3½ h. P. M.	- -	81.15

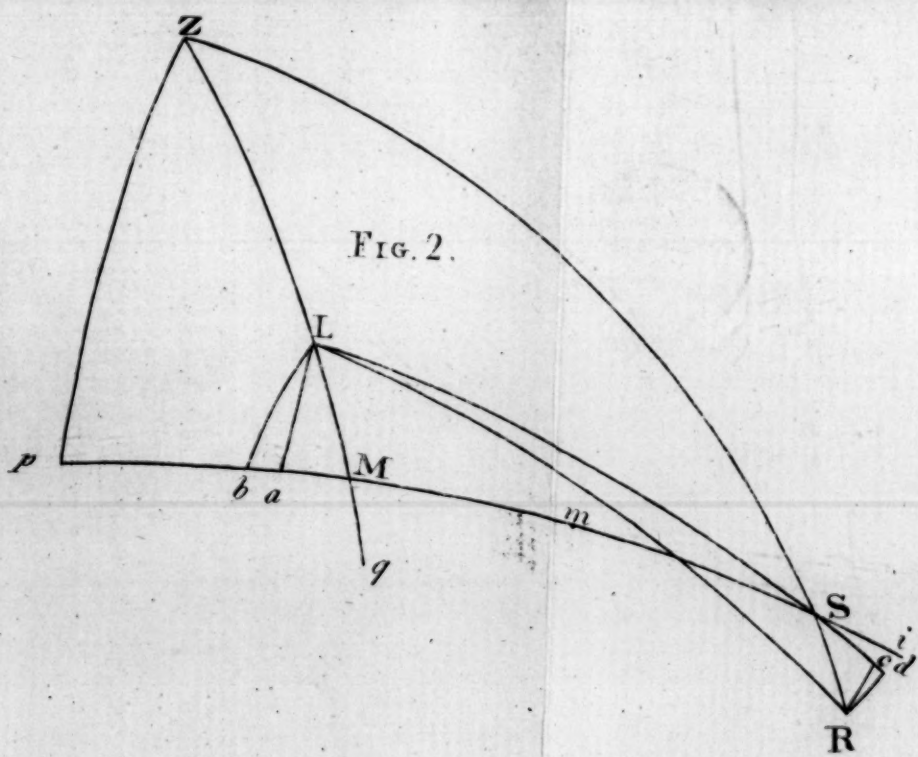
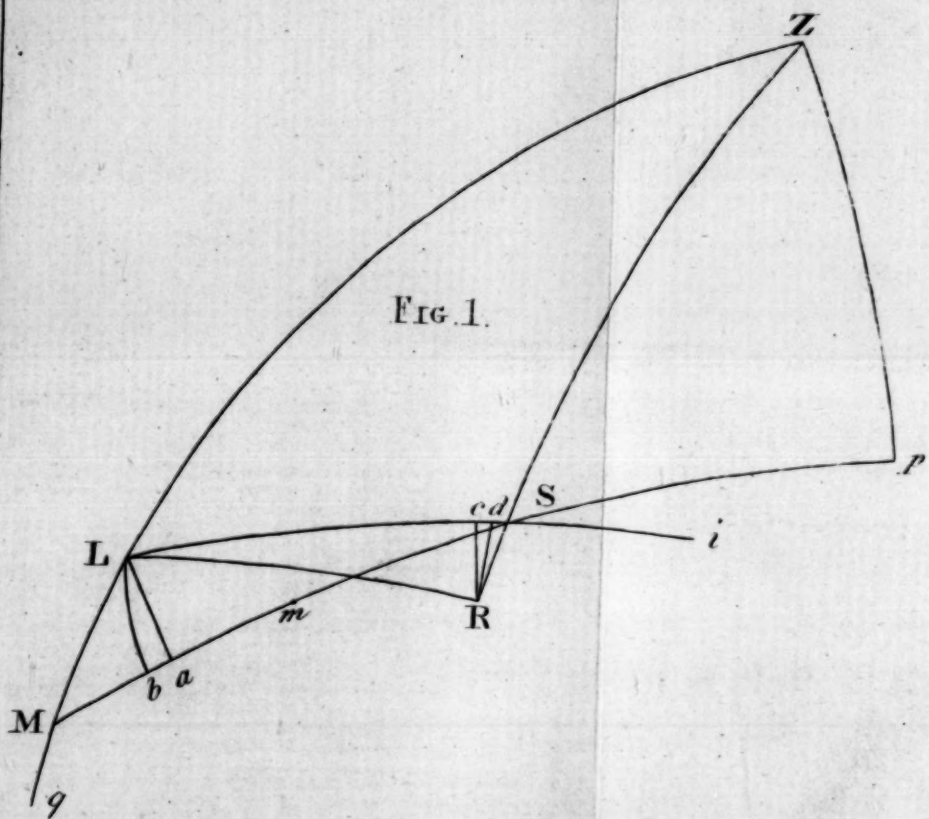
Proportion of the West Wind to the East for every Month, deduced from Observations made at Hawkhill from 1764 to 1771 both inclusive.

N. B. The South Wind, and all to the West of the Meridian, are reckoned West. The North Wind, and all to the East of the Meridian, are reckoned East.

Months.	W. wind.	E. wind.	Months.	W. wind.	E. wind.
January,	22.0	9.0	July,	17.9	13.1
February,	18.6	9.6	August,	21.3	9.7
March,	17.6	13.4	September,	20.4	9.6
April,	15.9	14.1	October,	23.9	7.1
May,	14.5	16.5	November,	22.0	8.0
June,	15.6	14.4	December,	20.0	11.0
For the whole year, 229.7 West, 135.5 East.					

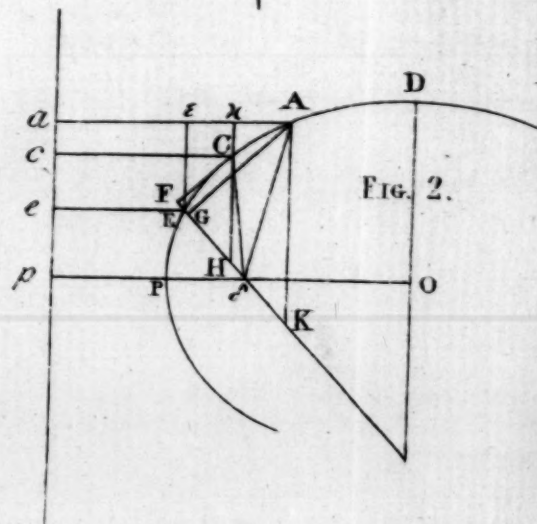
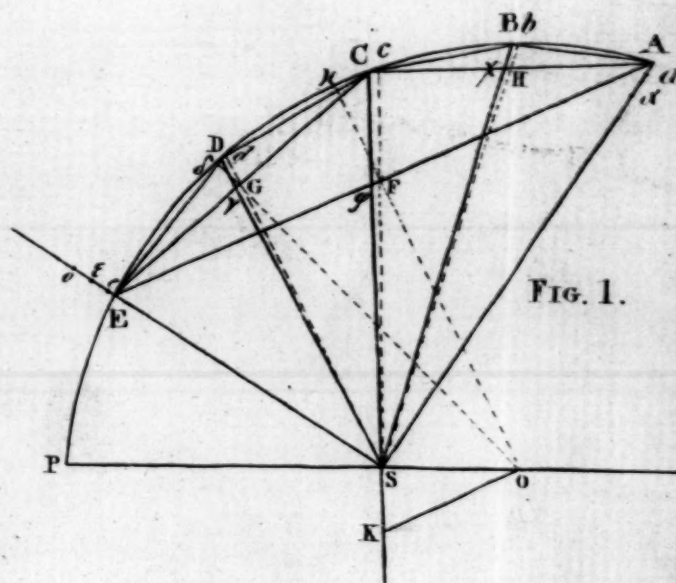
END OF PAPERS OF THE PHYSICAL CLASS.

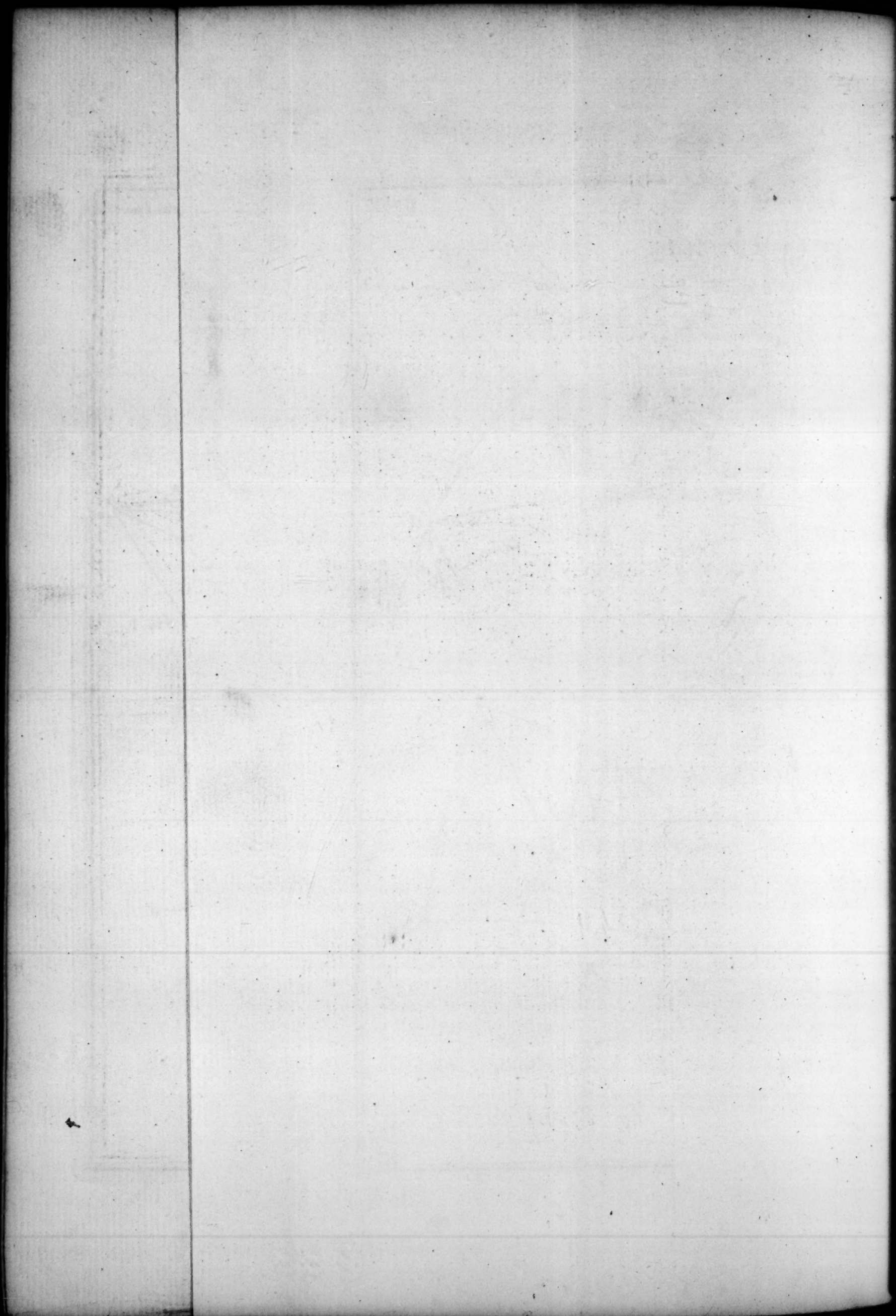
N° VII.



N° XI.

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II.

PAPERS OF THE LITERARY CLASS.

THE UNIVERSITY OF CHICAGO

II.

PAPERS OF THE LITERARY CLASS.

I. ESSAY *on the* ORIGIN *and* STRUCTURE *of the* EUROPEAN LEGISLATURES. By ALLAN MACONCHIE, Esq; Advocate, F. R. S. EDIN. and Professor of Public Law in the University of EDINBURGH.

P A R T I.

Of the Period previous to the Conquest of the Western Empire.

[Read by the Author, Dec. 15. 1783.]

I N T R O D U C T I O N.

THE fall of the feudal system was accomplished, in the principal states of Europe, at a period when the revival of learning had diffused in society a spirit of reflection, and communicated, to the better sort, some knowledge of the history of the Greek and Roman republics. As it was, in general, the kings who conducted the attack on the privileges of the feudal nobility, the principal part of the spoils had fallen naturally to their share. But the people were warlike, the nobles were still animated with the pride of rank, of family, and of their ancient consequence, and men, in general, had begun to speculate on their rights, and were unaccustomed to perceive, with satisfaction, the whole powers of government centred in the crown.

Hence the rights of the kings, of the nobility, and of the people, came to be a matter of general discussion: And as men are usually prejudiced in favour of the wisdom of their remote ancestors, and derive their more common notions of their political rights from what was customary in ancient times, the merits of the dispute were universally supposed to turn on the historical question of fact, What constitution was adopted by the original founders of each particular nation.

HENCE the first researches into the ancient history of the European governments were made with a view to support the tenets of political factions. Those who wished to gain the favour of courts laboured to prove the ancient sovereignty of the Gothic kings, and founded their systems on the despotic powers of the leader of a conquering army, and the absolute nature of a right of conquest; from whence they inferred, that the privileges of the aristocracy were usurpations on the crown, and the rights of the people the grants of its bounty. The partizans of the people again endeavoured to trace the political rights of the commons to a remote antiquity, and exhibited them as understood and exercised in the fullest manner in the earliest ages of the constitution; and they contended, that the happiness of those times was to be restored only, by the people resuming the constitutional powers which kings and nobles had alternately usurped. In fine, those who had imbibed from the Greek and Roman classics, or from family-connections, a profound reverence for aristocratic virtues, together with a proportionable aversion to plebeian manners, delighted to espouse the cause of the falling nobility, to display the ancient powers of the order, and to confute their antagonists, by tracing the circumscribed limits of the royal prerogative in remote times, the oppressions under which the commons laboured, and the little importance they possessed in national affairs.

IN this way, opinions with regard to the original structure of the European governments entered into the creeds of contending

ing factions ; and though these, in course of time, ceased to be the subject of professedly polemical writing, their influence is still sensible in guiding the views of the historian, and blunting the discernment of the philosopher and politician. The historiographer of France, even in these days, maintains the absolute legislative authority of the Merovingian princes. The Abbé MABLY, and English authors of no inferior reputation, Lord LITTELTON, Dr STUART, &c. affirm the remote antiquity of the representation of the commons ; and MONTESQUIEU and HUME have conferred their sanction on the aristocratic system. When a controversy is thus circumstanced, men of information are apt to indulge scepticism, and abandon the subject ; while second-rate authors seize it as lawful game, court popularity, by asserting errors that suit the taste of the times, and treat those with abuse who venture to reject them.

BUT there is, in fact, no period where there is better encouragement to hope that an enquiry may be pursued with success. The very scepticism of the literary world, which has begun to escape from the factions of the last century, if not suffered to mar its industry, will give enlargement to its views, and candour to its disquisitions. Many important facts in the history of rude nations, akin to those which founded the Gothic governments, have been ascertained : Many ancient records, to which the public had formerly no access, have been published ; and the efforts of great men, during the present century, to render history an object of philosophical speculation, have roused a spirit of enlightened observation, and taught persons, possessed of literary curiosity, how to direct their researches.

I FLATTER myself these observations will afford me some apology, for presuming to treat of a subject which has formerly drawn the attention of so many persons of the first abilities. My sentiments on it are the result of an enquiry, to which duty, as well as inclination, prompted me ; and, if they have no other merit, I trust they will at least be attended with
the

the advantage of suggesting an object for the labours of the society, highly interesting to us as citizens, as well as lovers of science.

WHEN we consider, with impartiality, the controversy about the ancient European constitutions, the first reflection that suggests itself is, that there must be some foundation in truth for the different opinions that have been adopted with regard to them. The partizans of each of the three systems produce evidence which goes a certain length in supporting it. There is, therefore, reason to suppose, that all the systems are chiefly erroneous, in so far as they are exclusive of each other; and that there must be an hypothesis, which, if discovered, would solve every difficulty, and involve in itself the doctrines of all the systems, to a certain extent.

PROCEEDING on this idea, and reflecting what this hypothesis may be, we are soon satisfied that it must be some very simple one. It is agreed on all hands, that the conquerors of the empire were in a very rude state of society at the æra of their settlements. Their disposition to emigrate as nations is alone sufficient to demonstrate, that husbandry was very imperfectly practised among them, and that their principal dependence was on their flocks and herds. In such circumstances, we may be assured, that the practice taken notice of by CÆSAR and TACITUS, *arva per annos mutant et superest ager*, still prevailed; and, of course, that as yet exclusive and permanent property in land had not been generally introduced, and that a separation of professions was unknown. Their situation, therefore, created no call for an improved jurisprudence, or for much exertion of legislative wisdom; and without this call, laws cannot be numerous, nor government complicated*.

BUT

* EVEN so late as the period since which the Swedish laws have been preserved, there are traces of the same migratory state of society having prevailed. "Coluerunt discreti
"et diversi," says SHERNHOOKE, "ædificiis transitoriis, et in annum aut mensem positis:"
Wherefore

BUT it is not enough to be assured, that the arrangements of society among the conquerors were extremely simple, or that an independence, natural to rude men, still prevailed, and was equally inconsistent with despotism in chiefs, and with that spirit of subordination, and systematic structure of laws, on which civil liberty depends. We must endeavour to learn exactly what the structure of society among the Gothic nations was, while still remaining in their original seats; and to ascertain the influence which settlement, in the cultivated provinces of the empire, where laws and government had been long established, necessarily produced on the political situation of the conquerors.

A VERY slight view of the history of Europe points out abundant materials for this extensive enquiry. The nations of this continent appear to have followed almost the same route to civilization, advancing only with more or less celerity, in proportion as they were situated in countries more or less fruitful, and more or less exposed to foreign intercourse. At the commencements of history, we find the rising republics in the neighbourhood of the Mediterranean possessed of institutions and traditions which indicate that they had recently emerged from that situation in which the more inland nations on the north of them still remained. After a few centuries had elapsed, Gaul and South Britain are found, at the invasion of CÆSAR, a transcript of Greece and Italy and Spain, when banishing their kings and establishing republics. Germany, more inland, retained still her rude form, her extensive confederacies, and disposition to emigration; while Finland, Caledonia, and Scandinavia, were little different from a North American wilderness. These countries, however, became formidable before the fall of the western empire; and Scandinavian tribes crossed the Baltic,
and

Wherefore he adds, the *leges vetustissimæ* directed the farmer to have a house for himself, and *trinas* for the slaves, cattle and corn, he might carry about with him in his journeyings, to be put up when he sojourned in one place, "perinde ut fepes excepta tantum
" ea quæ villam includeret," p. 295.

and repopled the countries which the conquerors of the Romans had abandoned. Germany then proceeded as southern Europe had done before her. She became fit to coalesce with Gaul under the government of the Franks; and petty states, rising on the coasts of the Baltic and German ocean, addicted to navigation and military adventure, restored in the north somewhat of the early ages of Greece and Italy.

IN the mean time, the feudal law, characterised by its domestic subordination, its tenures, its hereditary offices, and its titled nobility, and destined to create very lasting and very singular impressions on the European governments and manners, began to appear in the empire of the Franks. The wealth of Gaul naturally made the inconveniences arising from the imperfection of the German laws, be felt there with extreme severity. Men accordingly had there recourse to the expedient which they have universally resorted to for protection, wherever the progress of property has outstripped that of law. When law is in its infancy, and wealth has accumulated, though the political union is loose, and the authority of the magistrate feeble, the domestic authority of the heads of families is strong, and the union among their branches firm and intimate. The love of power, therefore, induces the opulent to extend their households, by employing their surplus wealth in engaging retainers; and the desire of safety prompts the less opulent to court admission into these little societies, and to promise support in return for protection. Hence the personal relation of patron and client was established; and the great importance of this relation, in turbulent times, naturally led men to have recourse to the Roman arts of conveyancing, (which were still preserved among the natives) for ascertaining its obligations, and rendering it permanent and adequate to the protection of their property. In this way, lands, already used as the means of purchasing retainers, came also to be impledged in constituting this relation; which, of course, from being personal, temporary, and dependent on mutual inclination, gradually

dually became indissoluble, hereditary and real. The family of MARTEL endeavoured to avail itself of the feudal combinations, in order to strengthen its own authority, and to introduce some firmness into the subordination of the citizens. By these means, they grew into the constitution of the state, and were enabled, during the convulsions which tore it in the fall of that house, to reduce every political institution in the French empire, under the forms of their arrangements.

SPAIN, when advancing by similar steps to Gaul, was overwhelmed by the Saracens, in the beginning of the eighth century. But as Catalonia soon after fell under the dominion of CHARLEMAGNE, the feudal tenures naturally found their way into that province, and were afterwards diffused through the rest of Spain, which was reconquered piece-meal, and chiefly by combinations of adventurers, who had to defend as well as conquer their acquisitions; and who must have found, that the feudal tenures were institutions extremely well suited to their situation. The Anglo-saxons, already accustomed to the personal relation of vassalage, and, through their connections with the continent, beginning to employ the feudal tenures, received them, at the establishment of the Normans, as the laws of their conqueror. The other European nations were, however, in different circumstances. As they were possessed of little wealth, their combinations for its protection were less general and less consolidated; and as they had escaped conquests by nations where the feus obtained, they adopted them only by slow degrees, and in a very partial manner. Among nations, as among individuals, the practices of the more skilful are imitated by those who are less accomplished and informed. Hence the northern kingdoms imported the feudal laws, because they were the laws of their more cultivated neighbours; because they were better calculated than their own loose customs, to ascertain their rights; and because it flattered the vanity of their grandees, to bear titles similar to those of the dignified nobility of France and the German empire.

pire. As in those nations, however, the feudal law was a plant of foreign growth, it was seldom able to acquire the vigour it possessed in its native soil. The restraints and forfeitures, which the Lombard lawyers had ingrafted on it, were frequently rejected; its titles of honour very often remained empty names, without political consequence; and, as it was in this manner employed merely for show, or for the ascertaining of private rights, much of the ancient constitution of the government was preserved unimpaired.

If these observations are in any measure just, the history of the constitution of the different European nations may be much elucidated by institutions ascertained to have existed in their sister countries, during the corresponding periods of their progress. The rise of the constitutions of the Greek and Italian states will derive light from what is known of the Gaulic, German and Scandinavian tribes. The Norwegians, Angles, Saxons, Jutes and Danes, of the seventh, eighth and ninth centuries, will be found to resemble the Germans of CÆSAR and TACITUS. The constitutions of the Anglo-saxons, of the Franks before the feus, of the Visigoths in Spain, and of the Norwegians in Iceland, ought to be extremely similar. And the more modern governments of Denmark, Sweden, Poland and Hungary, may be expected to retain more of the ancient Saxon and Scottish constitutions, than can be expected in the present British government, new modelled by the feudal law, and subjected, for ages, to the gradual but powerful influence of legislative wisdom and national cultivation.

HAVING recourse, as occasion requires, to the ample field of evidence pointed out by these observations, I shall endeavour to ascertain the form of government of the Gothic nations in their original seats; I shall examine the alterations it underwent upon their settlement in the Roman provinces; and I shall attempt to trace its progress and revolutions under the predominancy of the feudal system*.

PART

* This last part is not published in the present volume.

P A R T I.

SECTION I. *Of the Government of the German Nations while in their original Territories.*

THE German nations, when described by CÆSAR and TACITUS, exhibited the same disposition for emigration and conquest, which afterwards, in the times of ALARIC and CLOVIS, gained them possession of the Roman provinces. We may, therefore, look into the structure of society, which these great authors describe, for the causes of this restless spirit; and we may likewise infer, from the permanency of a temper so characteristic of national manners, that, during this long interval, the political circumstances of the Germans had continued nearly unchanged. Having, therefore, recourse to the lively picture which CÆSAR and TACITUS have left us, a little attention to the general circumstances of the Germanic nations will enable us to perceive in it, with sufficient precision, the forms of their constitution, and the nature of their government.

THE Germans lived in a country intersected with woods, rivers and mountains. However much, therefore, they were inclined to indulge in the indolence of the pastoral life, their country did not permit them to reside, like Tartars, in moveable habitations. Hence they sojourned in annual huts, and cultivated a little spot of ground for a crop, in aid of the produce of their cattle. Hence, too, they found it every where necessary to have strong holds, to which they carried their property in time of danger. These holds or *pagi*, as the Greeks and Romans called them, were the natural resort of the tribes in their neighbourhood, and seem to have been every where the first embryos of the towns and little states with which ancient Europe so much abounded. The *pagus* was usually situate on an eminence, on

an island in a river, or in the recesses of a wood ; and it was fortified by palifadoes and mounds of earth.

THE point of union, which was thus formed among a few tribes, necessarily produced assemblies of the whole warriors belonging to them, and the election of one of their chiefs to be their king or common leader. He held his office for life ; because it was men almost independent that gave it him, who never doubted but that they could deprive him of it at pleasure, and who continued him in it, because they had no motive to change him for another *. It was likewise usually conferred at his death on a person of his family. No distinction could be less invidious, or therefore would more readily fix the suffrages in favour of a candidate, than his relationship to a deceased chief. Thus it is said, *Reges ex nobilitate sumunt*. The chiefs of the tribes that resorted to the pagus were the natural counsellors of the king, as their influence was the principal means of engaging the warriors in any common measure. These chiefs were, no doubt, like the kings, usually elected out of particular families. TACITUS thus mentions the election of the chiefs of the subordinate tribes : “ *Eliguntur in iisdem conciliis principes qui jura per pagos vicosque reddunt. Centeni singulis ex plebe comites, concilium simul et auctoritas adfunt.*” *De Mor. Germ.* c. 12.

BUT though each pagus acknowledged, in general, no superior, yet the circumstances of society induced numbers of them to confederate ; and, when wars happened, a common leader of the confederacy was chosen of course. Men who live on the produce of herds

* DR STUART, and some other authors, have laid it down as certain, that these chiefs held their offices only for a year. I cannot, however, discover any good authority for this opinion, though favoured by MONTESQUIEU, contrary to the spirit of his system. It is opposed by the universal practice of rude nations. The appellation of kings, applied universally to the chiefs of rude tribes, is inconsistent with it. And as the kings of modern Europe were always understood to hold their offices for life ; and as, in general, the great provincial magistrates, in the ages after the conquest of the empire, did so likewise, unless deprived, there seems every reason to believe, that the office of a German chief was equally permanent.

herds can subsist together in great bodies; and the leisure they enjoy, and the whole habits of their lives, prompt them to engage in military enterprises. In this way, leagues for offence, and, of course, for defence likewise, are universally formed; and the confederates, in order to carry on their common undertakings, naturally choose a leader, whose powers endure as long as there is use for them. Thus, says CÆSAR, "Quum bellum civitas aut illatum defendit aut infert, magistratus qui ei bello præfint, ut vitæ necisque habeant potestatem deliguntur. In pace nullus est communis magistratus, sed principes regionum, atque pagorum, inter suos jus dicunt, controversiasq; minuunt." STRABO observes the same of the Lucanian states, a part of the ancient confederacy of the Samnites: "Τον μὲν ἐν ἄλλῳ χρόνῳ (viz. εἰρήνῃ) ἐδημοκρατεῖτο· ἐν δὲ τοῖς πολέμοις ἤρειτο βασιλεὺς, ὑπὸ τῶν νεμομένων ἀρχάς." *Lib. 6. 254.*

THESE leagues, of a number of cantons or pagi, seem to have been attended, in perhaps every nation under heaven, with one very important institution, viz. a distribution of the confederates into regular numbers. A great body of men, who carry on war for a considerable length of time, must soon perceive the advantage, and even necessity of order and arrangement; and the most simple of all arrangements, is the regulating by numbers the contingents that each pagus should furnish. As soon again as this measure is adopted, each pagus is under the necessity of taking a similar method for raising and managing its contingent. Each tribe belonging to a pagus will, of course, be called on to furnish a certain number, and each great family in the tribe a portion of this number. By this means, every canton, and the parts of a canton, come naturally to be characterised by their respective contingents, and the whole country itself seems to be arranged into a series of divisions for military purposes. "Definitur et numerus: says TACITUS, centeni ex singulis pagis sunt: idque ipsum inter suos vocantur, et quod primo numerus jam nomen et honor est." *De Mor. Germ. cap. 6.* We find

find this species of arrangement, not only in all countries where the Germans established themselves, but among the Israelites, as appears from the Mosaic institutions; among the Tartar nations, as far back as their history reaches; among the ancient states of Greece* and Italy; and the Roman legion itself seems to have derived from the same source its original form †.

It is natural to suppose, that, when a confederacy of neighbouring pagi had long subsisted, a feeling of somewhat of national union will be apt to arise. The common leader, occasionally chosen for a war, will be so often elected, as at last to retain his powers for life. He will therefore become a king, like the chief of a pagus, and will be a princeps regionis, with several principes pagorum, in such a subordination to him as the chiefs of vici, or of primary tribes, were originally to the chiefs of pagi. These combined pagi again may become the allies of a great and less consolidated confederacy. Thus TACITUS describes particularly the great confederacy of the Suevi; and he enumerates above thirty of the nations belonging to it. CÆSAR says ‡, That each pagus or nation belonging to this confederacy sent forth 1000 men to war every summer; by which means, as it consisted of an hundred pagi, an allied army of 100,000 men was annually formed. But TACITUS again mentions, that, in one single nation of the Suevi, viz. the Semnones, there were an hundred pagi. It appears, therefore, that the
Semnones

* HOMER speaks of decuriæ as known;

Πολλὰι κεν δικάδες δεινοτάτω οἰνοχοίῳ. Il. lib. ii. v. 128.

And he attributes to NESTOR the institution of the Greeks fighting by tribes and curiæ;

Κριν' ἀνδρας κατὰ φυλὰ κατὰ φρεσας Ἀγαμέμνον

Ὡς φρεσιν φρεσιν ἀρηγὴ φυλὰ δὲ φυλοῖς. Il. lib. ii. v. 362.

† It is remarkable, that the nature, universality and antiquity of this institution should have escaped President MONTESQUIEU's observation. He attributes it to the Merovingian princes, CLOTAIRE and CHILPERIC, and says, it was introduced into both France and England, in order that each district should answer for any robberies committed in it. *Esprit des Loix*, lib. 30. c. 17. Dr STUART has entertained more just notions of it. *Dissertation on the English constitution. Note, p. 231.*

‡ De Bello Gall. lib. 4. cap. 1.

Semnonēs were themselves a national confederacy, at the same time that they were only a single ally in the great league of the Suevi.

WE have evidence, that this military arrangement coincided with the natural distinctions of tribes and families. At the same time that TACITUS mentions the former, he observes as to the latter, That "non casus nec fortuita conglobatio turmam aut cuneum facit, sed familiæ et propinquitates." And CÆSAR mentions, that lands were occupied "gentibus cognationibusque *."

SUCH being the general arrangement of the Germans, it is easy to perceive the nature of those assemblies, about which there has been so much discussion. All writers agree in the gravity and decorum of the assemblies of savages. The chief sits in council with the aged, the warriors forming a circle around them. The chief, or the seniors, begin the deliberation, but all take a decent part in it, and the whole resolve; "the consent of the youth being as essential as that of the old †." Again, after the warriors are subjected to a degree of military order, we may reasonably conjecture, that it will be employed in their political assemblies. All rude nations love parade; and as, on such occasions, it contributes much to decorum, as well as discipline, their assembly must tend to become a military review, at the same time that it retains the character of a political and religious convention. It is true, the descriptions of CÆSAR and TACITUS do not countenance this notion of

* THWROCKS, or rather perhaps an anonymous author of a chronicle, as old as 1358, when mentioning the settlement of the Hungarians in Panonia, under their seven leaders, may also be urged in support of this opinion. "Et unicuique exercitui, capitaneum specialem præficientes, centurionesque ac decanos, more solito constituerunt. Et unusquisque exercitus 30,857 continebat. Nam in secundo eorundem de Scythia egressu de centum et octo tribubus ducenta et sedecim millia, de unaquaque, scilicet tribu, duo millia armatorum, excepto familiæ numero eduxisse perhibetur." Scriptores rerum Hungaricarum, 4to, v. i. p. 100.

† PEN's letter to the Pennsylvanian traders. See also KOLBEN of the Hottentots. Hist. Gen. des voyages, t. 6. p. 500. Also COLDEN's history of the six nations, &c. &c.

of order and regularity in the German diets. At the same time, as TACITUS relates, that they assembled in arms, it can scarce be doubted, that, by degrees, the regularity of a military review would be introduced. It is, indeed, not easy to conceive, how the vast multitudes of armed men, mentioned as assembling on public affairs, could observe any order, unless arranged in regular divisions. We know likewise, that the Tartars assembled in their *curiltay* in this manner, each tribe arranged under its proper banner. We know, that the ancient Greek *ecclesia** and the Roman *comitia* were also military musters and reviews. We know, that the assemblies of the Weapontact in modern Europe were likewise employed for this purpose. And we know, that the Franks, who attended the assemblies called *mallum*, *placitum*, and *parliament*, were obliged to appear in arms †, and those who had banners, to carry them along with them. The Irish, in the same manner, wore arms in their national and provincial conventions. And I shall afterwards have occasion to observe, that the *pospolite* in Poland, and the ancient diet of the German empire, assembled in a military form. We may reasonably then hold, that the structure of the different gradations of assemblies, among the ancient Germans, was extremely uniform, and wore a military aspect. In each assembly, its proper chief would preside, accompanied with a council of the chiefs of those tribes which resorted to it; and the warriors

* HOMER thus relates the assembling of the Greeks in diet when besieging Troy :

ἰστυχωνίῳ
Ἰλαδὸν εἰς ἀγορὴν. Il. lib. ii. v. 92.

† THE assembly of the Franks in the *campus martius* of the cities of Gaul, described by GREGORY of Tours, is manifestly a military review. “ Transacto vero anno, iussit “ (sciz. Clovis) omnem cum armorum apparatu advenire phalangem, ostensuram in campo martio suorum armorum nitorem ;” and he is mentioned as going through the ranks and examining their condition, lib. ii. c. 27. And when, under the second race, the Franks were called forth to assemble in military array, their magistrates were named *capitanei*, and the meeting a *placitum*. *Capit. A. D. 807*. This military appellation is common to all the great magistrates in both the Gothic and Slavonic nations. Vayvode, bannus, heretoge, are often translated *capitanei*, *duces*, &c.

riors of such tribes would attend in military array, under the chiefs of their subdivisions. At any rate, we are certain, that the warriors attended in person, and in arms, whether in regular array or not; and every person, in the least acquainted with the character of rude nations, will be persuaded, that the personal presence of the warriors was not a matter of mere form. It is only by the opportunity of persuasion, which numerous assemblies afford, and by that deference to the authority of persons of eminence, and that contagious enthusiasm which are there felt, that men, untamed by laws or cultivation, can be induced to pursue common measures. Hence national diets are the great engine by which leaders conduct affairs, before government acquires its powers: And accordingly, attendance on them is among the first duties of the citizen that are enforced. But when government has once attained its energy, kings and magistrates have no occasion for numerous councils, in order to accomplish their purposes. On the contrary, they dread them as rivals or masters; and they know, that the less formidable they can render them, by diminishing their numbers or their influence, their own power becomes in proportion uncontrolled*.

THERE is, however, abundance of direct evidence, that the warriors were not mere spectators of the deliberations of their chiefs in the German assemblies. TACITUS expressly mentions their approving or rejecting, by certain known signs, the proposals or advices that persons, distinguished by their functions, their age, descent, eloquence, or reputation in war, thought proper to offer. And he, in particular, remarks, that those who were of consequence enough to deliver their sentiments in this manner, pretended to no right to command compliance with them, but only hoped to influence or persuade.

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* AND again, when government becomes feeble, there are examples of national assemblies reappearing. In the fall of the western empire, the government, finding itself unable to animate the torpid and disjointed mass of the Gaulic nations, attempted to rouse its powers by the aid of national assemblies. SIRMOND not. ad Sidon. apolin. p. 245. See also DUBO's Hist. Cret. t. i. p. 241,—255. And to a similar cause is chiefly to be attributed the entry of the plebeians into the European legislatures.

THE accounts left us by TACITUS, of the powers exercised by these assemblies, scarce require any commentary. They were held regularly at stated intervals, and also on occasion of any extraordinary occurrence. Religion was employed to preserve moderation and decency in them, and feasting to promote sociality and good humour. Without doubt, every affair that created a public interest was there agitated. We find accordingly, that capital crimes were there tried, and probably no where else; since even the leaders of the nation in war could not punish military offences without the sanction of the priests. And, in general, it is only a popular assembly, or a priesthood, that can, with safety, venture to award punishments, in ages where revenge is virtue*. An individual that presumed to condemn on his own judgment would have the whole relations of the criminal, and, of consequence, in process of time, the whole nation for his foe. It is stated by LIVIUS, as one of the great causes of umbrage against the last TARQUIN, that he took upon him to try citizens without the aid of councils.

THE functions of the chiefs, we may reasonably judge, were, in general, ministerial. Even in battle, they conducted their armies rather by example than by authority. We may be sure, therefore, that, in peace, where the expediency of obedience is less obvious, their authority would be still weaker; and that, on all occasions, when any exertion of power was to be made, they would seek for a sanction to their conduct from the judgment of others. In judicial matters, there can be no doubt that they performed merely the functions of magistrates, not of judges. They received a large proportion of the fines, which were the punishment of crimes. This itself shows, that it could not belong to them, who were to reap a profit from the punishment,

* AND war, rather than a prosecution at law, the usual consequence of an injury. See the Rules, introduced by the Anglo-saxon laws, for restraining these private wars within certain limits. *W. L. L. Sax. passim.*

ment, to decide on the propriety of inflicting it* ; whereas, if it was their business to apprehend and accuse, to take the judgment of the judges, and to carry it into execution, the fine was no more than a necessary reward to stimulate their activity in repressing wrongs, and compensate the risk, as well as labour, which, in the infancy of government, must attend this duty. Independently, however, of this general presumption, the history of all the ancient judicatures in Europe affords every where the most convincing evidence, that the chiefs of the German and other conquering tribes exercised only ministerial powers in matters of judicature. I can, however, but just touch on it. In the first ages after the German conquest, we find the slaves of the kings, and of the provincial chiefs, exercising most frequently, in the administration of justice, the functions of their masters. These functions then must have been purely ministerial ; for we know that no slave, nor even an emancipated person, could bear witness where a freeman was concerned ; and most certainly, therefore, could never have been his judge. Accordingly, the effects of this state of the judicial power are equally conspicuous and extensive. The functions of the king in the trial of peers in a bed of justice in France ; the functions of the high steward of England, the representative of the king in the trial of British peers ; the functions of every baron, or deputy of a baron, in the court of the barony, of the bans and vayvodes in Hungary and Poland, of the lagmen in Sweden, of the sheriff and hundreder in England † ; in short, the di-

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stinction

* In the east, where the priesthood has stripped the people of the judicial power, no part of the fines for delinquencies are paid to the judges.

† I QUOTE the following statute as evidence, not only of the distinction being observed in Scotland, but of the anxiety of our ancestors to separate the judicial and ministerial functions : " Statuit dominus rex quod nullus justitiarius vicecomes vel ballivus, sedeat " ad judicium faciendum super appellatione et responsione coram eis facta. Sed cum ad " judicium venerint ; exeant de curia ; et libere tenentes de curia judicium faciant ; et re- " vocato justiciario, vicecomite vel ballivo, in curiam, judicium penes eos factum coram " ipso iudice reddatur." *Quon. attach. cap. 66.* There is a similar regulation in the establishments of St LEWIS, from which, no doubt, the law of the Scottish barons was borrowed.

distinction between the judges of the fact and the law, which is to be found almost universally in nations arising from a rude state, all manifestly flow from this common source, and, of consequence, unite in establishing it as a principle of importance in the history of the public law of Europe. In all rude nations, the laws are few, simple and precise; and it never occurs to their imagination, that any doubt can arise about the interpretation of them. When, therefore, their public assemblies have, on the accusation of the injured, or of the chief, convicted a person of a violation of the law, the pronouncing, as well as executing the sentence, is committed, as a matter of course, to the chief, though he was to profit by the conviction. In process of time, however, as law becomes complicated, there is room for doubt as to its interpretation, and the chief has recourse to the assistance of assessors or deputies for this purpose. Hence it happens, that the king, in almost all countries, is naturally the source, both of the judicial procedure by which courts of justice exercise their power, and of that magistracy which interprets the law, while the nation*, as naturally try, or delegate those who try, how far individuals have, in fact, committed the wrongs of which they are accused. We have examples in the kings and archons of Athens, in the kings, consuls and pretors of Rome, as well as in the Gothic magistracy, of the former powers, and of the latter, in the trials by the suffrages of the Greek and Roman tribes, of the county courts and national assemblies in modern Europe; and in those by the *δαιτηται* or arbiters, delegated from the tribes in Greece, the *judices pedanei*, delegated from the Roman tribes, the *scabini* from the Gothic and French tribes, the *nembda* from the Swedish, *hered fougdr* from the Danish, the *judices nobilium* from the Hungarian, and the lawmen, and their successors the juries, from the Anglo-saxon and Norman assemblies †.

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* Enlightened, but, I apprehend, by no means bound by this interpretation.

† This origin of juries has been controverted by very learned writers; but, I think, it is capable of being established. And the only plausible arguments against it seem to me.

THE constitutional authority of the German chiefs was probably not more extensive in political than in judicial affairs. It appears from CÆSAR, that they had the prerogative of regulating the annual establishments of the tribes*. This, however, it is likely, was no more than one of those *res minores*, about which, TACITUS says, the chiefs alone consulted: "Facilitatem partiendi camporum spatia prestant, arva per annos mutant et superest ager." In such a country, it was no greater prerogative in a king to distribute the lands, than to choose a camp for an army is in a general. It was, besides, a thing of that nature which a national diet could not well arrange; and, therefore, like the journeyings of a Tartar horde, was naturally left to the discretion of the chief, who would, however, consult, of course, with the subordinate chiefs on the business. The necessity of observing an order in the position of the tribe is likewise proved by the old laws of Sweden, which directed, with anxiety, the arrangement (*fitus* and *ordo*) of the cottages of villagers; and that they should be surrounded with a pallisado, in order, no doubt, that the inhabitants might make their defence with greater facility and effect, in case of an attack. *Sbernhook*, 295.

IN military affairs, the power of the chiefs would be most conspicuous. Although the choice of peace or war lay with the people, the conducting of military operations was necessarily committed to the chiefs. "De majoribus rebus omnes consultant, ita tamen ut ea quoque, quorum penes plebem arbitrium est, apud principes pertractentur," *Mor. Germ. c. 11*. A considerable

me to have arisen from not making sufficient allowance for those varieties which ought to be expected among institutions of the same kind in different countries, especially when the comparison is made at different stages of their progress.

* "NEQUE quisquam agri modum certum aut fines proprios habet, sed magistratus ac princeps in annos singulos gentibus cognationibusque hominum qui una coierunt quantum eis et quo loco visum est attribuunt agri, atque anno post alio transire cogunt." *Bell. Gall. c. 21*. "Agri pro numero cultorum, ab universis per vicos occupantur, quos mox inter se secundum dignationem partiuntur." *Mor. Germ. 26*.

considerable degree of coercion must be exercised by a leader, in a warlike expedition that continues for any length of time, and the natural privilege of distributing the booty, and the mere splendor of precedence, must augment greatly his influence.

THESE remarks, I flatter myself, will sufficiently point out my idea of the general structure of the German governments. Men, still cherishing the independence of the savage state, were forced to take measures for the defence of their rising property. That property occasioned wars, and wars introduced confederacies, military arrangements, and some degree of subordination. This subordination, however, did not deprive the minute tribes, of which the confederacies ultimately consisted, of their internal powers. A petty chief, with his tribe, formed by intermarriages into a clan, which claimed a common blood, were like the ancient *πατριαι* of Attica, or tribules of Italy; so many communities, possessed of judicative, legislative and executive powers, within themselves, similar to those exercised by the national confederacy. In this way, the form of society was nearly indestructible; and even those revolutions which wars occasion would probably contribute to preserve it. When a nation proved unfortunate, its parts coalesced under a different name, and the country was as formidable and warlike as before. Thus we find, in TACITUS, the names of nations which afterwards distinguished the conquerors of the empire. But, in his time, they, in general, were the names of only remote and inconsiderable states, which arose not to consequence till the confederacies, that were then predominant, had given way in the course of contending with the Roman arms. And again it seems reasonable to conjecture, that this warfare was the principal cause of preserving in vigour, during so many centuries, the spirit of emigration and conquest in Germany. By discouraging agriculture, it retained the Germans in the pastoral life, and, of consequence, cherished in them the inclination, as well as supplied the means for great enterprises. Hence those extensive confederacies, so
essential

essential to such enterprizes, and especially to wars carried on by barbarous tribes against the Roman legions, remained in full energy; and that progress in the arts of industry was prevented, which otherwise, in the course of a few centuries, would naturally have transformed every pagus into a little republic, and its ardent and active associations with its neighbours, into the cold alliances of agricultural states.

THE foregoing idea of the general form of the government of the Germans is strongly confirmed by what we know of the ancient constitution of Sweden and Iceland. Iceland was peopled by a series of Norwegian colonies, who fled their country, on the conquest of it by HAROLD *with the beautiful hair*, in *A. D.* 878. The colonies formed little communities with elective chiefs. These, by degrees, combined together, and held assemblies, under a common leader, in each of the four great provinces into which the ridges of mount Hecla divide the island: And, at last, these four provinces likewise confederated, and formed a republic, under one chief magistrate, in *A. D.* 928. The whole country was arranged into regular divisions, called provinces, hundreds, and reeps. The magistrates held their offices for life. At the diets, whether of the districts or of the nation, the magistrate celebrated religious rites; and it is, in particular, mentioned, that the lagman, or chief of the nation, performed human sacrifices at the alting, or great annual assembly. In it too, besides the arrangement of political matters, appeals were received from the provincial courts, and rejudged in its presence, and under its inspection, by the former judges; and the lagman's business was to carry into execution what the alting ordered. The judges of each district were called *repstio-rar*; and chosen, by the diet, among the wealthiest and most respectable of its members*. There was a succession of thirty-eight lagmans, which continued till 1262, when the republic was

* THESE probably corresponded to the *scabini* and *red boran*, or lawmen of the Franks and Saxons.

was destroyed by the Danes. I have taken this account from the Icelandic historian ARNGRIMUS JONAS, a native of the island, and a person who appears to have had abundance of authentic materials for his work.

THE Swedish government seems to have arisen in the same manner as that of Iceland, without the intervention of foreign conquest, or any very violent domestic revolution. The most ancient written law in Sweden is thought to be about as old as the period of CHARLEMAGNE. Each province had its own peculiar laws, which were collected successively into different codes, and, though not entirely the same, resembled each other extremely. SHERNHOOKE says, that the original courts of justice were the provincial assemblies or lagmansting, but that, in process of time, the provinces were divided into hæredas or trientes, and these again into fierdings or quadrantes. He says, the hæredas derived their name *from yielding a certain number of military forces*. In the province of Upland, they were termed hundreds, and the chiefs hundreders; for each district, whether hæreda or fierding, had chiefs*. The chief of the province was called lagman, which he translates legumvir, and was supreme magistrate, in both civil and religious affairs, as long as the provinces remained independent. The lagmansting judged appeals, and punished the chiefs and judges of hæredas and fierdings, who judged corruptly, or refused justice; and groundless appellants were likewise punished. After the provinces confederated, a common chief, or king, arose, and a national diet, called the landsting, was annually held. The lagmans and the dignified clergy, after the nation became Christian, formed the senate in this assembly. The people at first chose the lagmans. After the rise of a king, it appears from the ancient laws, that he had a right to select the lagmans out of leets, presented to him by the people of the respective districts. In some provinces, however, the lagman had rendered his office hereditary, had assumed

* This is precisely the arrangement of Denmark.

fumed the title of duke, and had usually named a deputy, who had the title of lagman. But GUSTAVUS ERICSON deprived both the people and the dukes of their privileges in this particular; and, of consequence, the lagmans ceased to form the senate of the national diet. "Ut enim ex iudicibus his, (so SHERNHOOKE terms the lagman), olim senatores, ita hodie ex senatoribus his, iudices provinciales constituuntur."

I SHALL not detain the Society with pointing out the perfect coincidence between the general structure of the ancient Swedish and Icelandic constitution, and that which I have attributed to the Aborigines in Germany; nor, after what is stated in the introduction to this paper, do I think it necessary to make any remarks to show, that I am entitled to avail myself of the resemblance in support of my opinion*.

INDEPENDENTLY, however, of the general form of the German governments, there were some circumstances in the national manners, which, though not immediately entering into the structure of the constitution, demand particular attention, because they contained sources of future revolutions. In the state of savages, or when men subsist on spontaneous produce, the political union hardly exercises any control over individuals. Nothing is more common than for a single person to propose to his tribe to make war; and, though the tribe reject the measure, to persist and go to war, either by himself, or with the assistance of a few that relish his proposal. Afterwards, when farms and herds are known, men still retain the right of avenging their own wrongs; and their new possessions are a sort of dominions, which they rule with a species of that

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* WHAT we know of the rude governments of the Welsh, Irish, Danes, and Caledonians, corresponds with the idea of that of the Germans, given in the text. Every where the clans chose their chiefs from particular races, and confederated clans chose their *reguli* and *subreguli* in the same manner. L. L. WALLIÆ, 164. and 184. Tractat. varii de Reg. Dan. WARE's antiquities of Ireland. LESLIE, BUCHANAN, *passim*. The tanist was chosen in the lifetime of the chief, and succeeded him at his death. Even at this day the Scots clans conceive they are entitled to change their chief, if he act disgracefully.

independent sovereignty, with which, in the savage state, they governed their own conduct. The *jus vitæ et necis*, competent to the Germans over wives, children and slaves, is mentioned by TACITUS. And we find, after the conquest of the Roman provinces, the rights of making war and levying troops every where recognised, as one of the powers of the private proprietor. It has been thought, that this right of waging war was a privilege usurped by the feudal nobles; but a further enquiry has fully proved, that it was an inheritance transmitted down to them from the origin of the nation. And, in fact, it was not an inheritance which had been preserved by them entire; for, either from apprehension of the end of the world approaching, or other causes of more steady operation, they had gradually submitted it to various restrictions; and, in particular, that they should only use it in revenge for personal injuries, and not on account of property or interest*. I have marked below, abundant evidence of this right of making war†; but I cannot forbear mentioning, in particular, that ARNGRIMUS JONAS tells us of a stranger that acquired vast estates to himself in Iceland, during the subsistence of the Icelandic republic, by a sort of right of conquest, resulting from his victories in wars with individuals‡.

IN a state of society where men retained such a degree of independence, it is manifest, that, in proportion as property became

* BEAUMANOIR coutume de Clermont, cap. 59.

† Ordenamiento de Alcala, tit. 29. HURBERTS Statuta Poloniæ, voce Guerra, p. 190. L L. Alfred. § 28. L L. Jnæ, § 9. L L. Edin. § 1. BOUQUET Droit public, p. 312. and 447. L L S. Steph. 1. Reg. Hungar. cap. 33. Codes of the Barbarians, *passim*: where family wars are supposed. L L. Roberti i. c. 20. Establishments de St LOUIS, et Ordinances des Rois de France, *passim*. But, especially, BEAUMANOIR, loc. cit. where he enters into a full detail about it.

‡ In Cook's last voyage, the following custom among the islanders of the Pacific ocean is mentioned: "If a person kill another in a quarrel, the friends of the deceased assemble and engage the survivor and his adherents. If they conquer, they take possession of the house, lands and goods of the other party; but, if conquered, the reverse takes place." Vol. ii. p. 173.

came considerable, it would be employed as means to gain power and protection. It is remarked by travellers, that all savage nations are hospitable, fond of interchanging presents, and of public feasting; but, among them, such indulgences are practised merely on account of the pleasure they afford, whereas the introduction of wealth in the sources of subsistence produces a variety of interests formerly unknown, and hospitality is practised, and presents bestowed, as the means of procuring security, distinction, or power. Hence among the Germans, every wealthy person had his retainers that frequented his table, and received from him protection, and various favours, in return for their aid, and for the presents they gave him. The chiefs, in particular, whose hospitality was supported by presents from the whole members of their tribes, naturally strove to distinguish themselves by their followers, and to attract around them the enterprising youths of the first families in the state. TACITUS * makes particular mention of this institution, and terms the retainers *comites*, probably a literal translation of the German *leuch* or *leude*. Authors have very frequently confounded these with the *principes vicorum et pagorum* which, in the preceding chapter, he distinguishes by the same name of *comites*; and where perhaps they have not confounded them, they have never, as far as I recollect, pointed out clearly the distinction between them. No two orders of men, however, could be more different; and the description of both is so accurate, that there seems to be no room for mistake. The chiefs of districts were elders, were civil magistrates, were military leaders, the heads of the nation, and the natural counsellors both of prince and people †, respectable by their experience, gravity and authority. But the retainers of the king were young men, his guards, his own personal partizans, supported by his munificence, courtiers of his favour, expectants of promotion from it, and sworn to maintain his

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glory,

* Cap. 13.

† KOLBEN of the Hottentots.

glory, and defend his person, at the expence even of their life *. After mentioning, that the young men were solemnly introduced into the diets, and there armed, TACITUS observes in substance †, that it was no shame to be numbered among the retainers of a great man. Distinction and power consisted in being always surrounded with a circle of chosen youths. They were an ornament in peace, and in war a safeguard. It was a matter of great emulation among the chiefs, which should have the bravest and most numerous retainers. The fame, merely of a superiority in this respect, was often decisive of a war. It was also a matter of emulation among the retainers, which should be first in favour with his chief; for there were different ranks among them according to that favour ‡. Their service was proportionably zealous. To have survived their chief in battle was an indelible disgrace. Their most sacred obligation

* I WILL not, however, presume to determine, that, even so early as TACITUS, the principes vicorum may not, in general, have been retainers of the kings. It would, no doubt, be a natural object of policy for the kings to extend their influence, by establishing a domestic relation between them and the sons of the chiefs of tribes; and these, when promoted to be chiefs, might, though absent, preserve their claim to this relation, while younger men, or persons of less consequence, would attend in the royal household.

† NEC rubor inter comites aspici. Gradus quinetiam et ipse comitatus habet, judicio ejus, quem sectantur: Magnaque et comitum emulatio, quibus primus apud principem suum locus; et principum, cui plurimi et acerrimi comites. Hæc dignitas, hæc vires, magno semper electorum juvenum globo circumdari, in pace decus, in bello præsidium. Nec solum in sua gente cuique, sed apud finitimas quoque civitates id nomen, ea gloria est, si numero ac virtute comitatus emineat: Expetuntur enim legationibus, et muneribus ornantur, et ipsa plerumque fama bella profligant. Cum ventum in aciem, turpe principi virtute vinci; turpe comitatui, virtutem principis non adæquare. Jam vero infame in omnem vitam ac probrosum, superstitem principi suo ex acie recessisse. Illum defendere, tueri, sua quoque fortia facta gloriæ ejus adsignare, præcipuum sacramentum est. Magnumque comitatum non nisi vi belloque tuere: Exigunt enim principis sui liberalitate illum bellatorem equum illam cruentam victricemque frameam. Nam epulæ, et quamquam incompti, largi tamen apparatus pro stipendio cedunt. Materia munificentiae per bella et raptus. Nec arare terram, aut expectare annum, tam facile persuaseris, quam vocare hostes et vulnera mereri: Pigrum quinimmo et iners videtur sudore adquirere, quod possis sanguine parare. *De Mor. Germ. c. 13. 14.*

‡ Somewhat probably like those of DAVID's mighty men.

tion was to defend him, and to promote his glory. War was, however, essential to retain them. The battle-horse, the victorious spear, were presents that they expected, and a plentiful and open board was the wages of their service. But it was to war alone that recourse could be had for the means of this munificence; for war, and not labour, suited the national temper, and furnished a necessary occupation to a numerous youth, averse to industry, and fond of adventure.

SUCH a body possessed the same resemblance to the chiefs of pagi, that the celeres and ἵππεις of the Roman and Lacedemonian kings bore to the senators of Rome and Sparta. DIONYSIUS, after describing the celeres, gives the following account of the ἵππεις, which may be properly enough subjoined to TACITUS's picture of the German leuchs: "Παρ' ἐκείνοις (τοῖς Λακεδαιμονίοις) οἱ γενναῖοτάτοι τῶν νέων φυλάκες ἦσαν τῶν βασιλέων. Ὅις ἐχρῶντο κατὰ τῆς πόλεως παρασπίσταις, ἵππευσί τε ἔσι καὶ πεζοῖς." *Dionys. Halic. Rom. Antiq. lib. 2.*

PART I.

SECTION II. *Of the Opinions, that the feudal Tenures and feudal Nobility commenced in ancient Germany.*

IT will naturally be expected, that, before proceeding to trace the government of the Germans after their establishment in the empire, I should take notice of certain opinions, entertained by authors of eminence, which are extremely adverse to the foregoing account of its original structure. It has been very generally thought, that, immediately upon the conquest, the governments became feudal; and M. DE MONTESQUIEU, and many others, hold, that the feudal subordination, and that hereditary nobility which made so distinguished a figure under the

the predominancy of the feus, actually subsisted in the woods of Germany *. Accordingly, this opinion has been urged in behalf of the system which exhibits the European governments as originally aristocratical, and is indeed so obviously allied with it, that it is certainly here necessary to consider a little the evidence on which it rests.

I. THE arguments for this extreme antiquity of the feus are founded, either on particular facts with respect to the peculiar manners of the Germanic nations, or on a general theory of the powers of the chiefs of rude tribes. The arguments of the former class, I must confess, appear to me to rest on very insufficient grounds. M. DE MONTESQUIEU traced the feudal tenures, in the presents of the war-horse, or of the bloody spear, and in the feasts which the German chiefs gave to their retainers in return for military service. But the Abbé de MABLY has justly observed, that, in the same way, the present European armies might be termed feudal vassals, holding their pay as a fief on condition of their service.

Dr STUART †, after very properly remarking, that territories are appropriated by communities, long before separate estates in land are acquired by individuals, lays it down, that the feudal relation of lands commenced in the subordination of the domains of the weaker communities to those of the stronger. He accordingly traces the origin of fiefs, in the dependent state of certain of the German and Gaulic tribes on others; and he confirms his hypothesis by the Cimbri, in the times of MARIUS, having demanded lands from the Romans, and offering, in return,

* I OUGHT likewise, perhaps, to take notice of the absolute sovereignty which has been attributed to the German kings, and of a representation, like that of the commons, supposed to have been known to the German tribes. But, I believe, these notions have never obtained much credit with the learned world, nor have been thought by it to rest on any thing more solid than the delusion of system.

† Dissertation on the English constitution, View of society in Europe, and other works.

turn, to assist them in their wars. But, in every age, nations find it expedient to arrange themselves under the protection of their more powerful neighbours; and where an alliance on equal terms is not to be obtained, the protection must be paid for by a tribute in money, or a contingent of troops, to be employed in executing the measures of the more powerful state. If such a stipulation is to be accounted a feudal contract, Athens and Lacedemon were the feudal lords of Greece, and Rome the feudal lord of half the known world. If there were any evidence, that alliances of this sort had been formed by a surrender of the territory of the protected to the dominion of the protector, or that territories were conceived to have been pledged in security of these treaties, then, no doubt, a striking resemblance between them and the feudal relation of modern times would be established. But no such evidence has been produced; and the fluctuating state of these alliances in Gaul, and the little progress the Germans had made in municipal law, can leave no doubt, that they were considered as merely personal contracts, and, in truth, possessed neither the solidity of a real vassalage, nor any connection with the subtle distinction between the dominium directum and dominium utile of land*.

Mr MILLAR has treated, with much ingenuity, the argument founded on the natural progress of rude nations†. He supposes, that the chief will naturally, at the separation of farms, have very large domains assigned him, great part of which he will employ in creating estates *at will* for his retainers, who, in return for this precarious possession, must labour or fight for him

* CÆSAR relates, *lib. 6. c. 11. de Bell. Gall.* That the Sequani and Ædui were the heads of factions in Gaul. The Sequani, by the aid of the Germans, so got the better of the Ædui, "ut magnam partem clientium ab Æduis ad se transducerent obsidesque, ab iis principum filios acciperint, et publice jurare cogerent, *Nilil se contra Sequanos concilii moturos, et partem finitime agri per vim occupatam possiderunt.*" Things changed after CÆSAR's arrival. The Ædui recovered their old clients, and they, and CÆSAR's other friends, the Remi, obtained many new ones.

† Origin of Ranks, p. 194. and 260.

him when he requires them. And, on this ground, and on the power thence conferred, and on the gradual surrender thus occasioned, of the estates of small proprietors, in consideration of protection, he explains the rise of a feudal relation in many distant countries, and that right of property and inheritance over their dominions, which travellers have ascribed to several kings in Africa and the east *, as Benin, Congo, &c.

I HAVE not, however, been able to discover any example of the retainers of the chief of a rude tribe holding lands from him in this manner. The lots of the Roman clients were as much their own as the larger estates of their patrons were theirs. The Italian equites received a war-horse and a ring, which may probably, at first, have been marks of royal favour, but we do not hear of usufructuary estates being allotted for them. Besides, we may be very certain, that, long after farms are separately cultivated, land is in great abundance, and to be got for the occupying. To present, therefore, in such times, a retainer with uncultivated land would be no favour; and as to lands which

* IN the quarto edition, Mr MILLAR stated this doctrine more strongly. He there lays it down, that the chief, in consequence of his ancient prerogative of presiding over the joint labours of the community, will, at the separation of farms, impose such conditions and limitations on the shares of individuals, as render them dependent on him for the continuance of their possession: And that, in this way, and by the extent of his peculiar domains, his authority becomes almost unlimited. It is evident, that, if this opinion were well founded, the government of all small and rude communities of husbandmen would be despotic, which is certainly not the case. And, accordingly, the argument on which it rests, though ingenious, admits of being obviated. The chief arranges the annual farms of rude tribes, and possibly, too, may preside over the labour of the tribe, if employed on a common farm; but, as may be reasonably conjectured from the independent spirit of uncultivated men, and, as is proved by the sales of lands by the American tribes, the chief is not, on that account, reckoned the proprietor of their territory. That, like the spontaneous produce of it, is accounted the common right of the whole freemen. And afterwards, when the annual farm becomes perpetual, or portions of land are seized upon by individuals, land is still in such vast abundance, that the spots, thus occupied, are naturally considered as the right of the possessor, as absolutely as the crop which he formerly reaped from his annual farm, or the prey which he seized in the sports of the field. Accordingly, we do not find, that, in any of the original monarchies of Greece, Italy and Gaul, the kings were ever considered as the proprietors of their dominions.

which a petty chief had slaves to cultivate, he would always find it prudent to retain the whole produce of them; because, if bestowed in hospitality, it would procure him much greater influence, than if the possessions, which yielded it, were distributed among a few individuals. Afterwards, again, when the greater part of the soil is appropriated by individuals, the districts which remain uncultivated are commons, over which the neighbouring inhabitants have established rights of servitude, and cannot be touched by a chief, till government is armed with all its powers*. Forfeitures and conquests are the true source of the overgrown domains of princes; and, where the latter have not happened, the former are scarcely able to compensate those dismemberments, which provisions for younger branches of the royal family necessarily occasion †.

WITH regard to the powers of certain African and Asiatic kings, and the circumstances of resemblance, observed by travellers, between the state of property in their dominions and the feudal arrangements of it in Europe, I shall only remark, that there are many particulars, connected with the feudal system, which are not characteristic of it; and, therefore, though discovered elsewhere, will not justify the inference that they resulted from feudal institutions. Thus, in many countries, armies are paid in lands; in many, every proprietor yields military service; and, in many, the opulent acquire consequence by means of clients and retainers. But the singular and distinguishing circumstance from which the feudal law acquired its character, and to which its more remarkable effects are to be ascribed, (such as, patrimonial magistracies, titles of honour, scale of subordination, and all those

* In Sweden, the king is vested with the districts which were formerly the common domains of communities. But no single community would bestow such a gift on its chief; whereas, where there is a number united under a king, every one may be prevailed upon to give up its own, in order to get government supported, by means of similar concessions from the rest.

† EVEN confiscation for capital crimes seems to have been unknown to the Romans before the *Lex Cornelia de proscrip.* Cicerō pro domo. Breach of fidelity was capital in both patron and client, but surely was not attended with forfeiture of estates.

those various shackles, by which it separated ranks, and rendered governments at once feeble and indissoluble) appears to be peculiar to Europe. I believe the nations of this continent alone afford an example of the relation of patron and client being made *real*; or, in other words, the patrimonial interests of both parties in a land estate rendered dependent on their fidelity in fulfilling its duties*.

II. THE feudal nobility make so conspicuous a figure in the history of the middle ages, that it is nowise surprising authors should have judged, that the German conquerors were originally subject to an aristocracy, which afterwards became the rulers of their new establishments. Accordingly, Mr HUME has held, that the principal proprietors of land were, without any election, the constituent members of the legislative assemblies of the Anglo-saxons. Most authors of eminence that treat of the feudal institutions have reasoned on the supposition, that there was an order of nobles which enjoyed the first rank of society among the German nations, at the period of their emigration. And M. DE MONTESQUIEU has specified the *leudes* or *fidels* (appellations which he considers as synonymous) as forming this order, and enjoying the exclusive capacity of being eligible to offices, and of receiving from the crown usufructuary grants of land, (called *fiefs* or *benefices*) on condition of military service. And while he considers the *leudes* as the same with those personal friends and retainers of the kings, termed *comites* by TACITUS, (an opinion which is now, I believe, universally admitted to be just) he represents them as a *noblesse d'origine* or patrician order, in which the antrustions, or those *leudes* who attended more particularly on the court, formed the first class. He quotes expressions, employed in the codes

* I AM besides apt, in the present case, to believe, that the historical facts resorted to have been misunderstood. *Histoire générale des voyages*, t. 6. p. 28. Ibid, p. 255. 263. 265. 264. 321. 318. The governments on the Gold Coast are obviously the production of conquest and superstition, and the nobles appear to be very independent, and to be proprietors of their estates.

codes of the Barbarians, or other ancient works, as evidence of his opinion ; and he confirms it, by attempting to show its fitness to explain circumstances in the history of the Franks. I shall, with due respect, state a different opinion, consider the evidence that stands against it, and support it by evidence which appears to me conclusive in its favour.

IF the Germans were distributed into clans, as the terms *cognationes, gentes, familiæ, et propinquitates*, used by CÆSAR and TACITUS as descriptive of their arrangements, clearly import, and as the laws in their codes, with respect to family feuds, prove, I think we may be certain, that no superior class of men, separated in blood from other freemen, was recognised among them. A clan always esteems itself of the blood of its chief. He is no more than the elder branch of a family, from which the meanest of his followers, as well as himself, are vain of deriving their descent. He owes their attachment to this prejudice ; and he knows too well the value of it, and how much his influence depends on the strength of it, to attempt weakening it, by laying claim to a distinction from superiority of blood, till combinations with his equals, or the progress of laws, inspire him with different views.

AMONG the Germans, no doubt, as well as every where else, the virtues and eminence of the parents reflected lustre on their progeny. And this, I conceive, is all that we ought to understand by the nobility of race, which is so often mentioned as belonging to individuals* ; though we believe, that the personal honour of being admitted among the domestic companions

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of

* THE ranks among the Israelites, before the captivity, illustrate this opinion. The whole freemen of every tribe held that they were descended of the same blood ; but each considerable branch of a tribe had a head, and each tribe a prince or chief ; and these elders, as they were called, being usually chosen from particular families, formed numbers of distinguished races in the nation.

It may also be observed, that, in rude times, men are determined, in their marriages, more by the personal attractions of women than by those of wealth, rank, and interest, which dictate so powerfully in cultivated ages. Hence, as in early times, women of the highest personal endowments will usually fall to the lot of men who have attained distinction ;

of the king was frequently conferred on the sons of those who had enjoyed it ; and that the sons of the subordinate chiefs, when candidates for the offices of their deceased fathers, derived great advantages from their descent.

THE arguments which have been used for a *noblesse d'origine*, neither aim at obviating the foregoing observations, nor rest on circumstances that have been found to bear examination. The monopoly of offices which the *fidels* enjoyed is evidently of no consequence, when it is understood, that the term *fidel* was applied to every person that took the oath of allegiance *. The *leudes* were certainly, in their origin, the personal companions of the kings ; and there is surely neither evidence nor argument for their having become a hereditary order previous to the Gothic conquests †. The high compositions, afterwards prescribed for wrongs committed against them, and still higher for those against the upper class of them, called *antrustions*, were no more than consequences of their personal connection with the sovereign, and their residence at court, where crimes incurred a triple penalty ‡. And the expressions, which are frequently to be found, relative to distinctions of rank among the freemen, instead of vindicating the existence of a patrician order, do, in fact, show, from the looseness with which they are used, that no such order was recognised in the state. Nothing may more safely be depended on as evidence that orders of nobility were unknown, than the want which authors betray of precise terms

distinction ; the families of chiefs will naturally, in the course of a few generations, acquire that marked superiority in character and figure, which travellers have often observed and mistaken for an indication of an original diversity in the race, and for the remains of ancient conquests and intermixtures of nations.

* BOUQUET Droit publique, p. 105.

† On the contrary, it is remarkable, that the signification of the term seems to have been enlarged on the continent till it lost its peculiar import, and became at last co-extensive with that of *fidelis*. Thus we read, "Cumque Lingonas civitatem venisset Dagobertus, tantam in universis Leudibus suis, tam sublimibus quam pauperibus justitiam," &c. FREDEG. Chron. § 58. See also § 87. In this way, it probably produced the term *lieges hommes* ; and it was no doubt natural enough for a king to call his *gens d'armes* companions.

‡ BOUQUET Droit publique, p. 103.

terms for distinguishing the superior ranks of persons. And accordingly, we have full evidence, that even the terms expressive of free birth and noble descent continued to be used indiscriminately, low down in the feudal times*.

THIS last circumstance, I apprehend, while it proves there was no patrician order among the conquerors, indicates also the origin of the genuine nobility of Europe. That nobility, as it is destitute of all titles of office or honour, exhibits no trace of owing any part of its lustre to the favour of kings, or to usurpations of magistracy. But its numbers, its prerogatives, the documents of its history, and its character, concur to prove, that it is the remains of nations of freemen, and derives its honours from having preserved, uncontaminated by servile or ignoble occupations, that high spirit which, as independent warriors, and as equals, the conquerors of Europe received pure and unadulterated from the bounty of nature.

THE state of persons in those European nations which have been farthest removed from innovation is entirely agreeable to this opinion. In *A. D.* 1480, about 300,000 nobles assembled in the diet of Poland. The Polish *pospolite*, or *comitia paludata*, is, in truth, an assembly of the freemen and warriors of the nation†. The simple burgeses can hardly be said to be

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* MONTESQUIEU quotes the term *optimates*, in the Burgundian laws, as evidence of a hereditary nobility. But it might express magistrates, or antrustions, or men of wealth. Nothing can be more loose than the manner in which terms of this kind were employed. GREGORY of TOURS often applies the term *valde ingenuus* to persons; and he seems to have no word for characterising the descendants of the *priores regni*, or *seniores civitatum*. Again, he says of one of his predecessors, "*Civis Turonicus de inferioribus populi ingenuus tam men.*" In a charter of Carloman, it is said, "*Et congruum obsequium sicut homines ingenui exhibeant, ne eorum ingenuitas, vel nobilitas vilescat.*" See also HEINEC. *Antiq. Germ.* v. ii. p. 52. *et seq.* Abrégé de Henault, *ad ann.* 1270. The terms *potentes*, *potentiores*, *boni generis*, *nobilioris generis*, *de nobilioribus*, are the only means even the laws have for describing persons of more consequence than others. BALUZ. p. 278. 334. &c. L. L. Visig. lib. 6. t. 1. c. 2. Mention is often made of the *ingenuitas regni* assembling. HOODY, p. 188. *Francs hommes* was, even in feudal times, a term synonymous with gentlemen or noblesse. THAUMASSIERE Notes on Assises de Jerus. p. 270.

† CROMER, bishop of Warne, says, "*Est pari dignatione Polonica nobilitas, nec est ulla in ea patritiorum comitumve discrimen.*" And PROCHNIEKEGO says, in his description

as yet naturalized ; for they cannot, by law, hold property in land without the liberties of their respective towns. And as to the husbandmen, their servile condition is well known. In the same manner, in Hungary, the nobles form the nation. The maxim of the lawyers is, *Nobilitas liberorum nomine intelligitur* *. The husbandmen are *servi adscriptitii*. The inhabitants of towns are still considered as emancipated slaves, whose testimony is admissible against a noble only for a debt of a florin, or under, unless the case happens within the city to which they belong. Hence the assemblies of even the subdivisions of their counties consist only of nobles ; and their decanus, or tithing man, who was always accounted a simple freeman in ancient times, in France, England, and Spain, and one, by no means, of much consideration, is accordingly, at this day, in Hungary, a noble and a magistrate, exercising the very functions which the ancient laws of the western nations attributed to their magistrate of the same name.

THERE can be no doubt, likewise, that, in Sweden and Denmark, before the emancipation of *adscriptitii*, freemen and nobles were precisely synonymous terms. And, in truth, only the emancipated *adscriptitii* of the crown appear to have there obtained the full right of citizenship.

EVERY person acquainted with the documents extant of the ancient state of Europe will find, that they so clearly refer to a distribution of ranks, similar to what we have been observing, that they cannot be understood on a different supposition. I shall cite one example of this which appears to be extremely decisive. In the succeeding parts of this paper, there will be occasion to found a great deal on the following general fact †, viz. That, at the conquest of the western empire, the former

scription of Poland, “ *Sunt in regno titulo Ducali insigniti, sed qui cum reliquis nobilibus jure utuntur communi—unde tanta omnium et par libertas.*”

* WERBEUCS, p. 10.

† Which almost every monument of the names in question may be quoted in evidence of.

mer arrangement of the Germans into *pagi**, centuries and decenaries, immediately appeared in the Roman provinces, which were every where divided and subdivided into districts, distinguished by these or corresponding names; and that, in each of these districts, the former species of subordination remained, *viz.* a chief, who was magistrate in peace, and leader in war, and an assembly of the warriors of it, competent equally for deliberation and action. The chiefs, or governors of *pagi* or large districts, were called, in the Latin of those times, *duces*, *comites*, *gardingi*, *banni*, *vaivodæ*, *heretogæ*, *aldermanni*. The heads of subdivisions were named after them respectively, *quingentenarii*, *centenarii*, *decani*. The higher magistrates had deputies that assisted them in their functions. These were called in Latin *vicarii*, and sometimes *vicecomites*; but, in general, they retained the names which, in their native language, belonged to their principals. Thus they had the titles of *gerefas*, *graffs*, *grieves*, *scyregraffs*, *margraffs*, *thiuphads*, *laghmans*, &c.

In process of time, the military and enterprising spirit of the conquerors was greatly damped, by the influence of their new situation, and various regulations were thought of to enforce compliance with their common duty, as defenders of their acquisitions. Among these, we find, in the code of the Visigoths, called the *fuerojusgo* †, a law which enacts, that, if the duke, count, or warden, failed in their duty, they forfeited their goods, and were liable to punishment; and that, as to all inferior persons, *viz.* those who called out the army, or those who were called out, then, “Non solum ducentis ictibus flagellorum verberati, sed et turpi decalvatione foedati singulas insuper libras auri cogantur exsolvere;” and that, if they had not substance to defray this fine, they should be condemned to slavery.

* *PAGUS* is used in the ancient codes and early writers as synonymous with *civitas* and *comitatus*. *Civitas* sometimes is employed for *urbs*, but generally in the sense of *municipium*, or of a subordinate state, comprehending a town and territory. *Greg. Tur. lib. 7. § 6. 12. 13. &c.* *CÆSAR, &c.* uses *pagus* in this way, *septem Helvetiorum pagi, &c.* The French *pais*, and German termination *gaw*, are supposed to be derived from it.

† *Lib. 9. tit. 2. l. 9.*

slavery. We have it, in the same law, specifically pointed out, that the persons subject to this punishment were the leaders of the subdivisions of counties, *viz.* the decani, centenarii, quingentenarii, thiuphadi, together with the servi dominici, or under-stewards and servile inhabitants of the royal domains, and all the freemen, arranged by their districts, whether Goths or Romans. Nor were the most considerable proprietors not included in this enumeration; for we find it directed, that those who are included in it should bring with them to the army the tenth part of their slaves in arms; and, in the preamble, it is complained, that people conceal their slaves, though possessed of multitudes employed in agriculture, and do not bring with them to the army the twentieth part of their family. On the other hand, the law not only shows, that it was destined to extend to every person, *cunctis populis regni*, but it specifies the majoris loci personæ to be the dux, comes, five etiam gardingus, all others being classed as inferiores personæ, although mention is notwithstanding made of seniors leading their vassals and commanding them in the army. Thus the circumstance, *viz.* superiority over vassals, that was afterwards so characteristic of feudal greatness, was not then held to distinguish a person from the rest of the nation; but a feudal lord is classed as a persona inferior, and is menaced with fine, whipping, and even slavery, equally with the lowest freeman.

We have here, therefore, a very clear description of the ranks of persons, *viz.* magistrates, freemen, and different classes of men of servile condition*; and we are sure, that there was no patrician order distinct from the other freemen, for several reasons: 1st, No class of persons is mentioned which could form such an order; whereas, in a law framed for calling forth the nation

* We find the same orders specified in the following passage of an ancient author: "Vetus consuetudo pro lege apud Francos et Suevos inolevit, ut si quis nobilis, ministerialis, vel colonus, coram suo iudice pro huiusmodi excessibus reus inventus fuerit, antequam mortis sententia puniatur, ad confusionis suæ ignominiam, nobilis canem, ministerialis fellam, rusticus aratri rotam, de comitatu in proximum comitatum gestare cogatur." *Lib. 2. de Gest. Federic. c. 18.* See also *L. L. Alleman. tit. 90.*

nation in arms, a nobility, belonging to a warlike people, must have made a distinguished figure. 2dly, It is inconsistent with the idea of a patrician order, to comprehend them within the description of personæ inferiores, and rank them under the lowest magistrates; yet it is manifest, that the enumeration in the law affords no other place for them. 3dly, Though the account given of the personæ inferiores shows there was no patrician order then recognised, that description of persons is enumerated among them, which afterwards, when the lower ranks were emancipated, and the third estate formed, was distinguished as noble. This class, therefore, by comprehending tithing men and hundreders, which, in the east of Europe, are offices held by nobles only, and also feudal lords and vassals, who, retaining the profession of arms, composed the noblesse of after ages in the west of Europe, proves, that we have no occasion to look farther for the origin of a patrician order, nor reason to imagine, that it is possible to discover it at the emigration from Germany, distinguished, by hereditary honours, from the rest of the conquerors. Accordingly, we find the Visigoths enacting, that every freeman of the national blood might offer himself as a candidate for the crown *. We find, that family names, so essential to patrician distinctions, were scarcely known in Europe till the twelfth century †. And we find, that the nobility

* MONTESQUIEU attributes the election of military leaders, on account of merit only, to the national adherence to the royal blood in the appointment of kings, and supposes the power of the mayors of the palace proceeded from the old custom, that *duces ex virtute sumunt*. But the monarchs who founded the European states were themselves duces, and owed their authority to that character, and not to their more hereditary one of being chiefs of petty tribes. Clovis, Alaric, Genseric, were the Brennuses and Arminiuses of their times. Hence the thrones of Europe were long, *de jure*, purely elective. The ancient form of creating a king was exactly that which TACITUS describes in the election of a dux; and the forms of the modern coronations are still that of an election. The major palatii was originally no more than the principal domestic of the king. We find majores domus nostræ mentioned in the plural number, and one quitting the office for a bishoprick. It was the great extent and growth of the household which rendered the mayors so powerful.

† SPELMAN, in his letters to ROSECRANTZ, says, He had not observed a *cognomen gentile* attributed to a Lombard, Frank, Saxon, or Dane, in the first ages after the conquest. Dr
HICKES

ty of Europe inherit neither appellations, as a peculiar order, nor titles of honour, nor official functions, except such as they manifestly have acquired from the feudal arrangements.

IN order to prevent mistakes, it is necessary to add further, that the intermixture of nations which the conquest produced, the freedom which men of professions that appeared ignoble to the conquerors possessed, and which men of servile condition acquired, and the differences which were constantly increasing between the wealth of individuals, necessarily introduced a real diversity in the ranks of freemen. Accordingly, in the more uncultivated districts, where the tribes or clans of the predominant nations retained, for some time, their genealogies, such tribes arrogated a degree of superiority; and, in the richer countries, though the clans soon disappeared, wealth and descent not only produced such distinctions as we know arise from them in civilized times, (distinctions then attended with no absolute separation of ranks) but, by means of the vast influence which the imperfection of law suffers them to usurp, introduced into the structure of society, and even into the codes of political institutions, a manifest tendency to the construction of that patrician order and aristocratic authority, which, during the feudal ages, nearly monopolised the sovereignty of the European nations*.

HICKES thinks, that the practice of using two names came to prevail in England in the Norman times; and that, during the crusades, the cognomen became a nomen gentile. *Dissert. p. 29.*

* THE Bavarian laws enact, that, in case of blows given in a tumult or meeting, the offender should pay a fine, "unicuique secundum suam genealogiam." And, in case of a sedition, while the principal persons engaged in it (called, however, simply homines) incurred a fine of 200 solidi, the populi minores and liberi paid only 40 solidi. *Tit. 2. c. 3. and 4.* And, in *c. 20.* five genealogies are mentioned which are entitled to a double fine; and the Agilolfingi, from among whom the duke was chosen, had right to a quadruple fine. In *A. D. 797*, the nobiliores paid, for disobeying a summons, four solidi, while the ingenui paid two, and the liti one. *BALUZ. p. 278.* By *L. L. Visig. lib. 6. tit. 1.* nobiles potentioresque personæ, ut primates palatii, eorumque filii, were not to be exposed to torment, on account of an accusation of theft, &c.; and a persona inferior was forbid to accuse nobiliorem se vel potentioorem.

II. *A DISSERTATION to prove that TROY was not taken by the GREEKS. By JOHN MACLAURIN, Esq; Advocate, and F. R. S. EDIN.*

[*Read by the Author, Feb. 16. 1784.*]

Non anni domuere decem, non mille carinæ. VIRG.

IT cannot well be disputed, that, till the Greeks were possessed of the art of writing, they could have nothing that deserved the name of history. When that art was introduced among them is uncertain; but there is reason to believe, it was not known to them at the time of the Trojan war, as there is no mention of any writing in all the works of HOMER; for the tablets, of which he speaks in one passage, did not contain any writing, but only marks or signs *. At any rate, it cannot be supposed, that writing was much known or practised, at that time, or indeed for long after. It appears from many charters, and other deeds, in this country, that men of the first families and fortunes in it could not, a few centuries ago, write their
f 2 names;

* Iliad. vi. 168. So EUSTATHIUS says expressly; and the reason he assigns, is, that letters were the invention of later times. He might have added, that it appears from several other passages in HOMER, that with him *γραφειν* does not signify *to write*, but *to trace* or *mark*; nor *σημα* a letter, but a mark, or sign, or credential. Iliad vii. 175. 187. 188. 189.; and Odyss. xxiv. 328. And *σημα* has unquestionably this signification in xxiii. 206. In this passage respecting *Bellerophon*, had Madam DACIER and Mr POPE adverted to this, they would not have translated this passage as they have done. *Ποτε δε οι σημαια λυγρα*, clearly means, that he gave him a token or credential that was meant to be destructive to him; and *γραφας θυμοφθορα πολλα*, that he traced in these folded tables many marks or signs, that gave to understand he was desirous of his death. There is, likewise, no mention of writing in the *Æneid*; which shews, that VIRGIL thought it the invention of later times.

names ; yet it is clear, from our having the use of coined money in commerce, and of cavalry in war, as well as from several other circumstances, that we were more civilized in those days than the Greeks could pretend to be when they first invaded Asia.

THOSE, therefore, of the Greek writers who chose to relate ancient events might shape their stories as they pleased. There could be nothing to contradict them, but a vague and confused tradition, (if there was so much) which, it is plain, would, at no time, be much regarded, and would soon be forgot or disbelieved, if the accounts of these writers were more flattering or favourable to their countrymen. Indeed, the Greeks seem all along to have had a natural inclination to pervert and falsify facts, and this drew upon them the severest reproaches from the lovers of truth.

——— *Quicquid Græcia mendax
Audet in historia.*

It may, perhaps, be said, that this is no more than the assertion of a Roman satirist, which ought not to be listened to. But it is easy to support JUVENAL's testimony by that of some of the most judicious Greek writers themselves. DIODORUS SICULUS informs us, that the ancient historians contradicted one another so much, that those of later times, who felt they had talents for writing history, abandoned all remote, and betook themselves to recent periods ; and THUCYDIDES shews, that not only with regard to ancient, but even as to recent events, the Greeks, his contemporaries, were very ill informed. In his introduction, he expresses himself as follows : " It is
" very difficult to find out the truth as to ancient affairs ; for
" men content themselves with reports as to past events, without being at the trouble to examine them, even though they
" relate to their own country." And he refers for proof, to the celebrated

celebrated story of HARMODIUS and ARISTOGITON. Of this he gives the detail in his sixth book; "Because neither the Athenians, or others, knew who was the tyrant at the time, or what was the real fact that happened." Poems had been composed, and statues erected, in honour of those men, as being the champions of liberty, and the deliverers of their country, by a bold stroke, in putting its tyrant to death; but it appears, from the narrative of THUCYDIDES, that all this was undeserved, and proceeded from a gross mistake; for they did not kill HIPPIAS, who was the tyrant, but his brother HIPPARCHUS; and him, not from a love of their country, or hatred of tyranny, but from very unworthy motives, which it would be indelicate to explain*.

IF the Athenians, the most enlightened people of Greece, could be so misled as to an event which happened but eighty-two years before the Peloponnesian war, what liberties might not HOMER take, in relating the circumstances of an expedition which preceded, by many centuries, the age in which he lived, and as to which, in all probability, there was no record or writing whatever?

IT is, indeed, supposed by the author of the life of HOMER, commonly ascribed to HERODOTUS, that he was only 168 years later than the Trojan war; but, from what THUCYDIDES says, it should seem that he thought he was long posterior† to it; and that, in fact, he was so, is apparent from several passages in his works. In one place, he says, that DIOMEDE lifted, brandished, and threw a stone, which two men, such as men are now-a-days, would not be able to carry; and, in another, that HECTOR lifted, brandished, and threw a stone, which two men, such as men are now-a-days, would not be able to heave from the ground into a cart; but so great a degeneracy could not have

* It took its rise from παιδεία. THUCYDIDES says ARISTOGITON ἐκείνῳ αὐτοῖ.

† Πολύ ὕστερον.

have happened in a century and a half. Besides, that he wrote from *report*, and knew nothing certain, he himself declares, in his address to the Muses, with which he introduces the catalogue of the Grecian ships and forces; which implies, that he was not only very long posterior to the event he chose for his subject, but that there was no record or history of it extant when he wrote.

MANY proofs might be brought of HOMER's story being generally disbelieved or doubted of among the ancients. A few shall be mentioned: And, first, I refer to the history of HELEN's birth. LÆDA, the wife of TYNDARUS, was delivered (it is said) of two eggs, in one of which were POLLUX and HELEN, in the other CASTOR and CLYTEMNESTRA. The former being the offspring of JUPITER, metamorphosed into a swan, were immortal; the latter, coming from TYNDARUS, subject to dissolution. And, it is added, that, when CASTOR drew near his end, his brother begged of the gods that he might be exempted from death as well as himself. This, it seems, could not be altogether complied with; but, to gratify him as far as fate would permit, it was decreed that they should live and die by turns. This is evidently an allegory, and generally thought to be an astronomical one. Now, if HELEN was not a real, but an allegorical personage, what becomes of the Trojan war?

THE story of the egg is not to be found in HOMER; but the alternate life and death of CASTOR and POLLUX is mentioned in the *Odyfsey**, though not consistent with a passage in the *Iliad*, to be afterwards quoted, which declares them both dead. Madame DACIER, in a note on this passage of the *Iliad*, says, that the fable of CASTOR and POLLUX was posterior to HOMER; but the passage of the *Odyfsey*, just now referred to, proves the contrary. HORACE seems to have thought, that the whole had been invented before HOMER's time, as he commends him for not having begun with the egg:

Nec gemino Trojanum bellum orditur ab ovo.

But

* xi. 302.

But there would have been no place for the compliment, if he could not have committed the fault. Be this as it may, the allegory is certainly of a very ancient date, and proves, that the authors of it did not believe HOMER's account of the Trojan war. Indeed, it goes further: It proves, they did not believe there had been a Trojan war at all; in support of which opinion, much may be said and has been said*.

2dly, IT is clear that HERODOTUS disbelieved, or very much doubted the Greek account of the Trojan war. That very intelligent and inquisitive historian informs us †, That he asked the Egyptian priests, whether what the Greeks alleged to have happened at Troy was *a foolish story* ‡? And he says they told him, that PARIS and HELEN, in their passage from Sparta to Troy, were overtaken by a storm, which drove them to Egypt, where some of their servants having disclosed the crime they had committed, PROTEUS, who then reigned at Memphis, seized and detained their persons, and the effects which they had brought with them: That when the Greeks came before Troy, and demanded back HELEN and her effects, the Trojans answered, that they had neither, both being in Egypt; but the Greeks, not believing this, besieged the town, and took it; and then MENELAUS, finding that what they had said was true, proceeded to Egypt, where his wife and goods were restored to him. HERODOTUS then quotes several passages of the Iliad to prove, that HOMER knew HELEN was not in Troy, but in Egypt, and had perverted the fact for the sake of his poetry. He adds, that he, too, subscribes to what was said with regard to HELEN's not being in Troy, for this reason, that it was impossible to believe PRIAM so devoid of understanding, as that he would have exposed

* See PERNETY's Fables Egyptiennes et Grecques dévoilées, tom. ii. And that the history of the Trojan war was no more than an allegory is taken for granted by GEBELIN DE LA COUR, in his Monde Primitif, ii. 400. ; and by BRYANT, in his Mythology.

† Lib. 2.

‡ Ματαιος λογος.

exposed his kingdom to destruction for a woman, if he had had her to deliver up.

THIS is a very curious passage. It proves clearly, that HERODOTUS, before he conversed with the Egyptian priests, doubted extremely of the account given by the Greeks of the Trojan war. He seems, however, to have altered his opinion, in consequence of what they told him MENELAUS had reported when he came to Egypt. That account, if true, removed, no doubt, the chief difficulty he had, which was, the incredibility of PRIAM's refusal to restore HELEN, when demanded by the Greeks; but, if he had reflected a little, he must have been satisfied, that it could not be true that HELEN was not in Troy during the siege. If she had not been there, it is impossible to believe that the Greeks would not have discovered this in less than ten years. They must very soon have come at the fact. When they did, they would have retired, if the recovery of her and her effects was the object of the war. Or, supposing that the hope of plunder would have made them continue it, yet MENELAUS surely would have gone for her to Egypt himself, or, at least, sent some person thither to enquire about her. Indeed, the assertion of the Trojans was, of itself, sufficient to have induced him to take that trouble. This has been remarked by RICCIUS*, who justly maintains, that HOMER's story as to this point is the more credible of the two: " Quis vero non
 " videat, magis præ se ferre speciem fabulæ id quod narrabant
 " sacerdotes, quam quod habet HOMERUS; estne, quæso, veri-
 " simile in ea ambiguitate perdurare voluisse Græcos decem
 " annos? Cum recipiendæ HELENÆ tam esset cupidus MENE-
 " LAUS, non mitteret statim aliquos in Ægyptum qui exquire-
 " rent, an vere apud PROTEUM illa detineretur? Non id om-
 " nino faciendum censerent frater AGAMEMNON supremus co-
 " piarum imperator, NESTOR alique duces? Quæ major absur-
 " ditas, quæ insignior imprudentia, quæ crassior stoliditas de
 " Græcis

* Dissert. HOMER. vol. ii. diss. 40. p. 216.

“ Græcis ducibus virtute et consilio celeberrimis confingi unquam possit ?”

SEVERAL ancient authors thinking it improbable that HELEN was in Troy, and seeing the force of the argument against the supposition of her not having been there, contrived a fiction to reconcile the two accounts, *viz.* That VENUS had created a shape or figure so exactly like HELEN, that PARIS carried the counterfeit* with him to Troy, believing it to be the celebrated Beauty herself. EURIPIDES's tragedy of HELEN turns entirely upon this ; and MUSGRAVE, in his notes, conjectures, that the story had been contrived by HELEN, in conjunction with the Egyptian priests, to re-establish her character after her return to Greece. It is plain, however, that, according to the Egyptian priests and HERODOTUS, HOMER has falsified the story in one material circumstance ; if so, it is impossible to say where he would stop.

3dly, Although THUCYDIDES, in his introduction, does suppose the truth of the Grecian expedition against Troy, and refers to HOMER for several particulars, yet he once and again enters the caveat, “ if any credit is to be given to his poems.”

Lastly, PAUSANIAS says, in so many words, that he gives more credit to HOMER than the *generality* of people do. The expression in the original† is rather stronger ; and it is certain, that several ancient authors, whose works unfortunately have not reached us, arraigned HOMER of falsehood, in treatises written on purpose to convict him of it§. I will not quote from LUCIAN, as his levity might be objected to, but only observe, that, if the common chronology be just, he had good reason to laugh at the supposition of PARIS falling in love with HELEN, or of her being an object of contention to Asia and Greece, as it is demonstrable that she must have been about an hundred years of age when Troy was taken ; for, according to the

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* Εἰδωλον.

† Οἱ λοιποὶ, p. 160. edit. 1696.

§ See an enumeration of them in the preface to Philostr. Heroica, p. 603. edit. 1709.

the common chronology, seventy-nine years elapsed between the Argonautic expedition and the taking of Troy; now she was the twin-sister of POLLUX, who was one of the Argonauts, and who fought and beat a famous boxer in the passage to Colchis, and therefore cannot be supposed, at that time, under eighteen or twenty. BAYLE, in his dictionary, has taken notice of HELEN's great age; and a witty author has compared her to the famous NINON DE L'ENCLOS, who made an assignation on the day she entered her eightieth year. But this ridicule strikes only against the common chronology; for HOMER says nothing to ascertain the period of time that elapsed between the two expeditions. From a circumstance, however, which he does mention, and which will be taken notice of by and by, it appears, that she could not be under forty when Troy was taken.

AFTER what has been stated, I may venture, I imagine, to proceed with less timidity than I otherwise could have done, to endeavour to shew, that the account given by the Greeks of their expedition against Troy is incredible and inconsistent with itself; and that (if ever there was at all a Trojan war) Troy was not taken by them, but that they were obliged, by those who defended it, to raise the siege, and retire with loss and disgrace.

SEVERAL of the arguments to be urged in the sequel upon this subject are taken from a very curious dissertation by a Greek author, DIO CHRYSOSTOMUS, who lived in the time of TRAJAN, and acquired great reputation by his works, from the purity of his style, and the elegance and depth of his sentiments and reflections. He has written two dissertations upon HOMER; in one of them*, he makes his panegyric as a poet; but, in the other†, takes him severely to task as an historian. The first mentioned, which is in praise of the poet, is taken notice of by almost every commentator who has published an edition of his works; but not one of them makes the least mention of the other. Hence it is not much known.

THIS

* Orat. lv.

† Orat. xi.

THIS last may be divided into two parts. The first part contains an account of the Trojan war, quite opposite, in most particulars, to that of HOMER ; and this, CHRYSOSTOM says, he made up, partly from information, which he too pretends to have obtained from an Egyptian priest, and partly from what appeared to him to be most probable. The other, and by far the most valuable part, is an argument to prove, that HOMER's account must appear, when examined with attention, to be false, absurd, and contradictory to itself. As the detail which CHRYSOSTOM gives is not vouched or authenticated in any shape, I shall state no more of it than is necessary for understanding the argumentative part of his discourse, which merits the greatest attention. CASAUBON, who writes some notes on this author, says of this dissertation ; " Dignus plane liber hic, quem legant " philologi, et quicunque in veterum scriptis cum judicio cupiunt " versari ; quamvis et pro HOMERO multa dici possunt."

It is not, however, my intention to translate this part of the discourse, nor even to abridge it, but only to select from it the arguments that appeared to me the most conclusive and striking, to enforce them by some additional considerations, and to add some observations that have occurred to myself in reading and reflecting on this very important and interesting article of ancient history.

ACCORDING to this author, HELEN, the daughter of TYNDARUS, king of Sparta, was, by far, the most beautiful woman of her time, and had a great number of suitors, amongst whom were MENELAUS and PARIS. The latter was preferred by the lady to all the rest, on account of the graces of his person and address ; and his magnificent presents obtained the consent of TYNDARUS, her father, who besides was desirous of connecting himself with Asia. Upon this MENELAUS, and the other Greeks, partly from resentment of the affront which they thought they had received, and partly from the hope of plunder, invaded

Troas. Many auxiliaries came to the assistance of PRIAM, and an obstinate and bloody war ensued, in the course of which great numbers fell on both sides; but the Greeks had all along the worst of it. They lost a great number of troops, and some of their bravest commanders. HECTOR, according to this author, instead of being slain by ACHILLES, himself slew both ACHILLES and AJAX; though HOMER, to cover this disgrace, has made the former, who was the bravest of the Greeks, perish by the hand of PARIS, the most dastardly of the Trojans, the latter by his own. At last, after suffering an infinity of hardships and losses, the Greeks were glad to retire as they best could. He gives a very long detail of the war; but, for the reason already mentioned, I enter not upon it, but proceed to the real evidence he offers of the falsity of the common story.

IN considering this matter, it will be proper to view the circumstances and situations of persons and affairs, as at four different periods: 1st, Before the voyage of PARIS to Sparta. 2^{dly}, As at the time of his arrival there. 3^{dly}, During the war. And, 4^{thly}, After the taking and sacking of Troy.

IT is, by no means, probable that PARIS would fall in love with a woman whom he had never seen; and still less so, that he would form the desperate and nefarious project of carrying her off from her husband, a powerful king, who lived at a considerable distance, and beyond seas.

CHRYSOSTOM might have added, that the force of this objection was foreseen; and that to obviate it, was invented what is called the *judgment of PARIS*; for it was not the shepherd of Ida that conceived this plan; he was put upon it by VENUS, who promised him success in reward of his having adjudged the apple to her.

BUT further, PARIS could not get a ship, or a crew, without the consent or connivance of his father; yet it cannot be believed, that PRIAM, an old, wise and good king, would give any countenance to such an undertaking.

LET

LET it be supposed, however, that PARIS, somehow or other, got a ship and crew, and arrived at Lacedæmon, when MENELAUS and her brother were absent, (for it is surely necessary to send them away); and let it be still further supposed, that he had been able to persuade her to forsake her husband, her child, and her country, and to follow, to her own eternal disgrace, a young adventurer to a strange land; yet still insurmountable difficulties stood in the way of his carrying her off. For it must be observed, that Lacedæmon was not a sea-port town, but a mediterranean place, being many miles up the country, as appears from the map; and further, that PARIS did not only carry off HELEN, but her effects, which consisted in bulky goods, such as, wearing apparel, carpets, tapestry, and vessels of different kinds. It was impossible, therefore, for PARIS to carry her off secretly. He must have done it openly and avowedly, and in the face of the sun; and a number of horses and carriages were necessary to transport the lady and her baggage from Lacedæmon to the sea-port. Now, supposing MENELAUS absent, is it possible to believe that his subjects would have sat with their arms across, and beheld the wife and the wealth of their king carried off by a handful of banditti?

It is not easy to figure a tolerable answer to this objection. The author of one of the spurious histories of the Trojan war in Latin felt its force, and to avoid it, pretends, that PARIS met with HELEN in the island of Cythera, near the coast of Sparta. But this is inadmissible; for, in the *first* place, HOMER expressly says, in a variety of passages, that HELEN was brought from Lacedæmon to Troy; and, *2dly*, Not only she, but all her valuable effects were carried off; and she certainly would not have these with her, when upon an excursion to an island in the neighbourhood.

WE come now to the period of the war. It is very surprising that the Trojans did not deliver up HELEN to the ambassadors
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sent from Greece, as the demand was not only founded in justice, but enforced by the threat of an invasion. It is still more surprising, that they should persist in their refusal, when they saw themselves attacked with 1200 ships and 100,000 men. What is most astonishing of all is, that they did not restore her upon the death of PARIS, but married her to his brother DEIPHOBUS. Here CHRYSOSTOM argues, and with great plausibility, that this is perfectly incredible, upon the supposition that PARIS had possessed himself of her by a crime; but by no means so if he obtained her in marriage with her father's consent; for then the grossest injustice was on the side of the Greeks; and it is not at all surprising, that the Trojans should have been willing to suffer the last extremities rather than submit. This last supposition is further confirmed by this circumstance, that CASTOR and POLLUX, the brothers of HELEN, did not go upon this expedition. They both were alive at the time of her pretended elopement*.

TEN years elapsed, after the elopement of HELEN, before the Greeks laid siege to Troy. This we learn from her lamentation over the dead body of HECTOR; for there she is made to say expressly, that she was now in the twentieth year of her absence from her native country†; and as it is agreed, that the siege of Troy lasted ten years, it follows, that the same period had elapsed from her being carried off to the landing of the Greeks in Asia. This circumstance CHRYSOSTOM has overlooked; but it seems to deserve attention. So long a delay cannot well be accounted for.

THE scholiast upon the above passage, who seems to have foreseen the observation, says, that this time was spent in assembling the Grecian army; but as the Grecian princes lived at no great distance from one another, and all their men were accustomed to the use of arms, it could not be difficult to bring them soon together; and if it be supposed, that they came to the place of rendezvous

* Il. iii. 236.

† Il. xxiv. 765.

rendezvous at different times during this long period, it is not easy to see how they could be subsisted; besides, it cannot be doubted, that MENELAUS would hasten the invasion as much as possible.

AT this rate, the beauty of HELEN must have been upon the wane when the siege began, and quite over by the time it ended. For which reason, Mr WOOD regrets, that HOMER introduced the circumstance into his poem, as it is far from being agreeable, and not at all material. He might have added, that it is not consistent with the excessive encomiums which even the old men of Troy bestow on her charms, in the tenth year of the siege; or the extravagant compliment they pay her, that it was not at all surprising the Greeks and Trojans should have suffered so much and so long for her. The probability is, that this circumstance was invented by HOMER to give an air of credibility to some others; particularly, to account for the absence of CASTOR and POLLUX. In the third book of the Iliad, HELEN expresses great surprise because she did not see her two brothers among the Grecian commanders. This was in the tenth year of the siege; and HOMER adds, "But they had both died at Lacedæmon a long time before." This proves they were alive at the time of the elopement; and that he thought it necessary to account for their not being at the siege.

THE Greeks, however, did at last make their appearance before Troy; but the town was not taken till after a ten years siege*. This is the most puzzling circumstance of all; especially when it is considered, that HOMER tells us it had been taken formerly by HERCULES with only six ships, and had by him been levelled to the ground.

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* M. FOURMONT, in a dissertation, in tom. 5. *des Mem. de l'Acad. des Inscrit.* pretends, that the siege began only three weeks or a month before the quarrel between AGAMEMNON and ACHILLES, which happened in the beginning of the tenth year; and that the rest of the time had been spent in expeditions against different places in Asia. M. FOURMONT says, unanswerable objections may be made to HOMER's account on the other supposition. The Abbé BANIER has written an answer to this dissertation, in which he proves, from several passages in HOMER, that the siege lasted ten years; but has been, by no means, able to answer the objections that arise from that supposition. See tom. 5.

THE Greeks, by HOMER's account, were always greatly superior in numbers to the Trojans and their auxiliaries; and, for more than nine years, they had ACHILLES with them *, whom HOMER has, on all occasions, represented as perfectly irresistible to the Trojans. How then came it about that the war lasted so long?

THE only answer that can be made to this is, that the Trojans kept within their walls as long as ACHILLES appeared; and this HOMER himself suggests †, though it is contradictory to several other passages, where it is said, that many battles had been fought, and great numbers slain on both sides.

BUT this will not prove satisfactory, when it is considered, that ANDROMACHE, in the interview she has with HECTOR in the sixth book, tells him, that the city was to be come at, and the wall easily scaled ‡; and that AJAX, AGAMEMNON, MENELAUS, and DIOMED, had three times attempted it. If so, what hindered ACHILLES to storm the town the day after he landed? How came AJAX, and the other chiefs, to be so long in threatening an assault? Madame DACIER, in a note on this passage, says, That the art of reconnoitering was not known, at this time, even to the Greeks. The absurdity of the answer shews the force of the observation. A wolf, fox, or other beast of prey, that wants to get into a fold or close where sheep or cattle are confined, would walk round it to discover at what place the fence was lowest.

BUT further, supposing the town to have been impregnable, how came the Greeks not to take it by blockade? They had a powerful fleet, the Trojans none; so that it was easy to hinder the town from being supplied with provisions by sea; and it was equally easy to have drawn lines around it, which would have cut off all communication between it and the country; the infallible consequence of which would have been, that the Trojans must have surrendered as soon as their stock of provisions

* Il. viii. 558.

† Il. vii. 352.; xviii. 287.

‡ Il. vi. 434.

fions was consumed. As the Greeks did not draw lines around the town, whilst, at the same time, we are told they threw up a rampart before their own ships, and as the Trojans received succours from their neighbours at different times, the fair conclusion is, that the Greeks were not masters of the country, nor superior to the Trojans in the field, but, on the contrary, found themselves overmatched. If it shall be said, that the art of drawing lines was not known to the Greeks, I answer, that the method they took to secure their ships proves the contrary to be true; and, had they been ignorant of that art, (if so simple an operation deserves that name), they never would have thought of the siege, as they had no artillery or machinery of any kind for making a breach in the walls: Besides, without any art or labour, they could have placed bodies of troops so as to intercept all the Trojan convoys.

HOMER admits, that the Greeks suffered more before Troy than any mortal man could relate*: That they lost a great number of men, many excellent officers, and that AJAX, ANTILOCHUS, PATROCLUS, and ACHILLES, the greatest hero of them all, perished in the expedition. This, of itself, affords a presumption that they were not successful. It is very improbable that ACHILLES fell by the hand of PARIS; the truth seems to be, that he died by that of a better man. HECTOR possessed himself of his armour, which is not at all surprising, if he slew its owner; but cannot otherwise be explained: For, as to the story of PATROCLUS dressing himself in the armour of ACHILLES, and being slain and stripped by HECTOR, it cannot possibly be true. ACHILLES was by far the strongest and stateliest of the Greeks: HECTOR was nothing to him; and PATROCLUS again was nothing to HECTOR, as is evident from the anxiety with which ACHILLES charges him not to encounter HECTOR. Now, when HECTOR did get ACHILLES's armour, he found he could not use it; and, therefore, HOMER † makes

b

JUPITER

* Odyss. iii. 105.

† Book xvii. 210.

JUPITER interpose to fit it to his body ; though, after all, the god did not perform the work sufficiently ; for HECTOR owed his death to fighting ACHILLES in that armour, as an aperture still remained near the throat, through which ACHILLES drove his spear. If then the armour of ACHILLES could not be used by HECTOR, how is it possible, that it could be used by PATROCLUS, who was so much inferior to him ? It is palpable, that he must have been almost as ill fitted with it as DAVID was with SAUL's. HOMER himself admits *, that PATROCLUS could not wield ACHILLES's spear, how then could he support, not to say march and fight, under the load of his armour ?

It cannot be denied, that ACHILLES fell during the siege ; and it is evident the Greeks must have been less able to take the town, after this and their other losses, than before. Accordingly it is admitted by HOMER and his followers, that they did not take it by *force*, but it is pretended they took it by stratagem. HOMER's account of which, is precisely as follows † : EPEUS made a wooden horse, into which ULYSSES and the Grecian chiefs went with a body of troops ; the rest of the Greeks burnt their tents, and set sail. Upon this, the Trojans came down, and, along with them, HELEN. She, attended by DEIPHOBUS, went three times round the horse, calling each of the Grecian leaders by his name, and mimicking the voice of his wife. This made them all, except ULYSSES, desirous to get out, or return an answer ; but he restrained them, and clapped his hand on the mouth of one of them, who was more eager to speak than the rest, and kept him gagged in that manner till HELEN retired. The Trojans then drew up the machine to their citadel, and held a consultation as to what they should do with it. Some were for cutting it up ; some for precipitating it from the rock ; but others thought it ought to be allowed to remain as a propitiatory figure. This last opinion prevailed, and the Greeks came

out.

* Il. xvi. 140.

† Odyss. viii. 500. ; iv. 271.

out of it, and, after an obstinate struggle, vanquished the Trojans, and plundered the town.

THE absurdity of all this is too gross and glaring to need refutation. VIRGIL saw well the objections to which it is liable, and, to obviate them, has strained his invention to the utmost, but in vain. According to him, this horse was huge as a mountain*; and it was necessary it should, as it was to contain an army in its belly. It fell to the lot of ULYSSES, MENELAUS, NEOPTOLEMUS, the maker EPEUS, and five other leaders, to enter this machine; which they did, with a body of armed men that filled it. The rest of the Greeks sailed to Tenedos, which was *in sight* †, and there *bid* ‡ themselves on the desert shore. The Trojans, thinking them gone for good, came down, and consulted about the disposal of the horse, as in HOMER. But upon LAOCOON, who opposed its introduction into the city, being devoured by two serpents, they put wheels to its feet, and ropes to its neck, and drew it up to the town, through a breach made on purpose in the wall. The Greeks at Tenedos returned at midnight, having the benefit of a bright moon-shine; and those in the horse having descended by means of a rope, opened the gates to them, and the Trojans, being buried in sleep and wine, were easily mastered.

EVERY person who reads this with the least attention must perceive, that VIRGIL had better have couched the story in general obscure terms, as HOMER does. By being particular, instead of mending the matter, he makes it worse; and there is one striking incongruity, into which it is astonishing he should have fallen. Tenedos, he says, was in sight; and, no doubt, it was; for its distance from the Trojan shore is but forty stadia, or five miles; it was a bright moon-shine, and Troy stood on a hill; how then could a *great* army be *bid* from the Trojans on a *desert* shore? At any rate, it is impossible, that 1200 ships could be concealed from them. They must have seen the fleet

b 2

at

* Æneid. ii.

† In conspectu.

‡ Conduunt.

at least. If so, it cannot be believed, that they would have made a large breach in their wall, when the enemy was so near. But it would be improper to dwell longer here. Since the town, it is admitted, was not taken by force, and since the stratagem by which it is alleged to have been taken is absurd and impracticable, the fair conclusion is, that it was not taken at all, and that we should have read the repulse of the Greeks in verse, if time had not envied us the works of the poets of Troy.

LET us now see what happened, according to the Greek writers, after Troy was, as they pretend, taken and sacked. If the Greeks had been, in reality, victorious, it is natural to suppose that they would have returned home in a body, in good order, observing due discipline and obedience to their general. But, instead of doing so, HOMER tells us*, that they quarrelled among themselves, differed about the course they should steer; that some went one way, some another, and that several were shipwrecked.

BUT this is not all: If the Greeks had been, in reality, victorious, those who returned would have been received as conquerors, with open arms by their families, and with acclamations by their subjects. But the reverse of this confessedly happened. AGAMEMNON, their captain-general, upon his arrival, was slain in his own house, by a villain who had debauched his wife in his absence. Would such have been his fate, had he appeared at the head of an army of conquerors? And not only was he himself slain, but, according to HOMER, all those who returned with him; yet this exploit was performed, he says, by ÆGISTHUS, with no more than twenty men; and he reigned seven years in AGAMEMNON's stead †, till he was assassinated, in his turn, by ORESTES. DIOMED was soon driven from his country, and NEOPTOLEMUS from Peloponnesus; and, according to the account of the former in VIRGIL, all who were concerned in the expedition

* Odyss. iii. 136.

† Ibid. iv. 530.

expedition against Troy were dispersed over the earth, and suffered every where remarkable hardships and distress,

Vel PRIAMO miseranda manus —

Æn. xi. 259.

THE wretched situation in which ULYSSES found his affairs at home is described, at great length, in the *Odyssey*, by HOMER himself. But unless it had been well understood, that the affairs of the Greeks before Troy were desperate, no set of men would have dared to have possessed themselves of his house, insulted his wife, and devoured his substance, as he could have returned and punished them in a few days; for we learn from HOMER * and HERODOTUS †, that the passage from Troy to Pthia and Sparta could be performed in three days, and Ithaca was not much further off.

ON the other hand, let us take a view of what (it is supposed) happened to some of the Trojans after the pretended capture and destruction of their town. ÆNEAS sailed with twenty ships, and a great number of people, to Italy, where he obtained a very good settlement indeed, for himself and his followers. So did ANTENOR; and, what is still more wonderful, HELENUS goes and occupies a part of Greece, establishing himself in Epirus. It certainly never was before heard of, that a conquered people sent out colonies to take possession of part of the country of its conquerors ‡.

I COULD offer many more circumstances and considerations in support of my proposition, partly from CHRYSOSTOM, (whose excellent dissertation I have, by no means, exhausted) and partly

* Il. ix. 663.

† Lib. ii. c. 117.

‡ SUCH is the account given by VIRGIL, DIONYSIUS HALICARN. and others; and it is generally followed. But it must be observed, that HOMER says nothing of HELENUS's settlement in Epirus, or of ÆNEAS's in Italy. On the contrary, he says, that ÆNEAS and his descendants reigned over the Trojans. See *Iliad*, and *WOOD's Life of HOMER*. This, however, seems as little reconcilable to the Greek account of the capture of the city as the other.

ly from what I have noted myself in the course of my researches on this question; but, were I to do so, this paper would swell to a treatise: Besides, I have said enough, I imagine, to undeceive men as to this matter; at least, enough to make them think upon it with attention and impartiality; which, if they do, I have no doubt that they will very soon undeceive themselves.

To conclude: As it is a matter of indifference to us, now-a-days, whether the Greeks or Trojans prevailed, there is no reason why the foregoing argument should be read with dislike or regret: On the contrary, it is the favourable side of the question; for, if it lessens ACHILLES, who had nothing but personal courage and strength to recommend him, it exalts HECTOR, whom his enemies admitted to be the best and bravest man of his nation; and, above all, it does justice to HELEN, the finest woman of antiquity, by restoring to her that character of which poetic calumny has too long deprived her.

Fortunati ambo! si quid mea carmina possunt. Æn. ix. 446.

III. *An ODE on the POPULAR SUPERSTITIONS of the HIGHLANDS of SCOTLAND, considered as the Subject of Poetry. Written by the late Mr WILLIAM COLLINS: And communicated to the ROYAL SOCIETY of EDINBURGH, by ALEXANDER CARLYLE, D. D. F. R. S. EDIN. Minister of INVERESK, and Chaplain in ordinary to his MAJESTY.*

INTRODUCTION TO THE POEM.

AT a meeting of the Literary Class of the Royal Society, held on Monday 19th April 1784, the Reverend Dr CARLYLE read an ode, written by the late Mr WILLIAM COLLINS, and addressed to JOHN HOME, Esq; (author of DOUGLAS, &c.) on his return to Scotland in 1749. The committee appointed to superintend the publication of the Society's Transactions, having judged this ode to be extremely deserving of a place in that collection, requested Mr ALEX. FRASER TYTLER, one of their number, to procure from Dr CARLYLE every degree of information which he could give concerning it. This information, which forms a proper introduction to the poem itself, is contained in the two following letters.

LETTER from Mr ALEX. FRASER TYTLER to Mr JOHN ROBISON,
General Secretary of the Royal Society of Edinburgh.

Dear Sir,

At the desire of the Committee for publishing the Royal Society's Transactions, I wrote to Dr CARLYLE, requesting of him an account of all such particulars regarding Mr COLLINS's poem as were known to him, and which were, in his opinion, proper to be communicated to the public. I received from him the
inclosed

inclosed answer, and he transmitted to me, at the same time, the original manuscript in Mr COLLINS's handwriting. It is evidently the *prima cura* of the poem, as you will perceive from the alterations made in the manuscript, by deleting many lines and words, and substituting others, which are written above them. In particular, the greatest part of the twelfth stanza is new-modelled in that manner. These variations I have marked in notes on the copy which is inclosed, and I think they should be printed : For literary people are not indifferent to information of this kind, which shews the progressive improvement of a thought in the mind of a man of genius.

THIS ode is, beyond all doubt, the poem alluded to in the life of COLLINS by JOHNSON, who, mentioning a visit made by Dr WARTON and his brother to the poet in his last illness, says, " He shewed them, at the same time, an ode, inscribed to " Mr JOHN HOME, on the superstitions of the Highlands, " which they thought superior to his other works, but which " no search has yet found." COLLINS himself, it appears from this passage, had kept a copy of the poem, which, considering the unhappy circumstances that attended his last illness, it is no wonder was mislaid or lost ; and, but for that fortunate hint given by JOHNSON, it appears from Dr CARLYLE's letter, that the original manuscript would, in all probability, have undergone the same fate.

STRUCK with the singular beauty of this poem, of which, I believe, no man of taste will say that Dr WARTON and his brother have over-rated the merit, I could not help regretting the mutilated form in which it appeared ; and, in talking on that subject to my friend Mr HENRY MACKENZIE of the Exchequer, (a gentleman well known to the literary world by many ingenious productions) I proposed to him the task of supplying the fifth stanza, and the half of the sixth, which were entirely lost. How well he has executed that task, the public will judge ; who, unless warned by the inverted commas that distinguish the

the

the supplemental verses, would probably never have discovered the chasm. Several hemistichs, and words left blank by Mr COLLINS, had before been very happily supplied by Dr CARLYLE. These are likewise marked by inverted commas. They are a proof that this poem, as Dr CARLYLE has remarked, was hastily composed; but this circumstance evinces, at the same time, the vigour of the author's imagination, and the ready command he possessed of harmonious numbers.

I am, dear Sir,

Yours, &c.

To ALEX. FRASER TYTLER, Esq;

S I R,

I SEND you inclosed the original manuscript of Mr COLLINS's poem, that, by comparing with it the copy which I read to the Society, you may be able to answer most of the queries put to me by the Committee of the Royal Society.

THE manuscript is in Mr COLLINS's handwriting, and fell into my hands among the papers of a friend of mine and Mr JOHN HOME's, who died as long ago as the year 1754. Soon after I found the poem, I shewed it to Mr HOME, who told me that it had been addressed to him by Mr COLLINS, on his leaving London in the year 1749: That it was hastily composed and incorrect; but that he would one day find leisure to look it over with care. Mr COLLINS and Mr HOME had been made acquainted by Mr JOHN BARROW, (the *cordial youth* mentioned in the first stanza), who had been, for some time, at the university of Edinburgh; had been a volunteer, along with Mr HOME, in the year 1746; had been taken prisoner with him at the battle of Falkirk, and had escaped, together with him and five or six other gentlemen, from the castle of Down. Mr BARROW resided in 1749 at Winchester, where Mr COLLINS and Mr HOME

were,

were, for a week or two, together on a visit. Mr BARROW was paymaster in America, in the war that commenced in 1756, and died in that country.

I THOUGHT no more of the poem, till a few years ago, when, on reading Dr JOHNSON'S life of COLLINS, I conjectured that it might be the very copy of verses which he mentions, which he says was much prized by some of his friends, and for the loss of which he expresses regret. I sought for it among my papers; and perceiving that a stanza and a half were wanting, I made the most diligent search I could for them, but in vain. Whether or not this great chasm was in the poem when it first came into my hands, is more than I can remember, at this distance of time.

As a curious and valuable fragment, I thought it could not appear with more advantage than in the Collection of the Royal Society.

I am, Sir,

Your most obedient servant,

ALEX. CARLYLE.

An

An ODE on the POPULAR SUPERSTITIONS of the HIGHLANDS of SCOTLAND, considered as the Subject of Poetry.

I.

H—, thou return'ft from Thames, whose Naiads long
Have seen thee ling'ring, with a fond delay,
Mid those soft friends, whose hearts, some future day,
Shall melt, perhaps, to hear thy tragic song.
Go, not unmindful of that cordial youth*,
Whom, long endear'd, thou leav'ft by Lavant's fide;
Together let us wish him lafting truth,
And joy untainted with his deftin'd bride.
Go! nor regardless, while these numbers boast
My fhort-liv'd blifs, forget my focial name;
But think far off how, on the fouthern coaft,
I met thy friendship with an equal flame!
Fresh to that foil thou turn'ft, whose ev'ry vale
Shall prompt the poet, and his fong demand:
To thee thy copious fubjects ne'er fhall fail;
Thou need'ft but take the pencil to thy hand,
And paint what all believe who own thy genial land.

II.

THERE muft thou wake perforce thy Doric quill,
'Tis Fancy's land to which thou fett'ft thy feet;
Where ftill, 'tis faid, the fairy people meet
Beneath each birken fhade on mead or hill.
There each trim lafs that fkimms the milky ftore
To the fwart tribes their creamy bowl allots;

* See the preceding letter from Dr CARLYLE.

By night they sip it round the cottage-door,
 While airy minstrels warble jocund notes.
 There every herd, by sad experience, knows
 How, wing'd with fate, their elf-shot arrows fly ;
 When the sick ewe her summer food foregoes,
 Or, stretch'd on earth, the heart-smit heifers lie.
 Such airy beings awe th' untutor'd swain :
 Nor thou, though learn'd, his homelier thoughts neglect ;
 Let thy sweet muse the rural faith sustain :
 These are the themes of simple, sure effect,
 That add new conquests to her boundless reign,
 And fill, with double force, her heart-commanding strain.

III.

Ev'N yet preserv'd, how often may'st thou hear,
 Where to the pole the Boreal mountains run,
 Taught by the father to his list'ning son
 Strange lays, whose power had charm'd a SPENCER's ear.
 At ev'ry pause, before thy mind possessest,
 Old Runic bards shall seem to rise around,
 With uncouth lyres, in many-coloured vest,
 Their matted hair with boughs fantastic crown'd :
 Whether thou bid'st the well-taught hind repeat *
 The choral dirge that mourns some chieftain brave,
 When ev'ry shrieking maid her bosom beat,
 And strew'd with choicest herbs his scented grave ;
 Or whether, sitting in the shepherd's shiel †,
 Thou hear'st some sounding tale of war's alarms ;
 When, at the bugle's call, with fire and steel,
 The sturdy clans pour'd forth their bony swarms,
 And hostile brothers met to prove each other's arms.

'Tis

* First written, *relate*.

† A kind of hut, built for a summer habitation to the herdsmen, when the cattle are sent to graze in distant pastures.

IV.

'Tis thine to sing, how framing hideous spells
 In SKY's lone isle the gifted wizzard "fits *,"
 "Waiting in" wintry cave "his wayward fits †;"
 Or in the depth ‡ of UIST's dark forests dwells:
 How they, whose fight such dreary dreams engross,
 With their own visions oft astonish'd § droop,
 When o'er the wat'ry strath or quaggy moss
 They see the gliding ghosts unbodied troop.
 Or if in sports, or on the festive green,
 Their "piercing ||" glance some fated youth descry,
 Who, now perhaps in lusty vigour seen
 And rosy health, shall soon lamented die.
 For them the viewless forms of air obey
 Their bidding heed **, and at their beck repair.
 They know what spirit brews the stormful day,
 And heartless, oft like moody madness stare
 To see the phantom train their secret work prepare.

V.

†† "OR on some bellying rock that shades the deep,
 " They view the lurid signs that cross the sky,
 " Where, in the west, the brooding tempests lie,
 " And hear their first, faint, rustling pennons sweep.
 " Or in the arched cave, where deep and dark
 " The broad, unbroken billows heave and swell,

" In

* COLLINS had written, *seer*.

† COLLINS had written, *Lodg'd in the wintry cave with*— and had left the line imperfect: Altered and the chasm supplied by Dr CARLYLE.

‡ First written, *gloom*.

§ First written, *afflicted*.

|| A blank in the manuscript. The word *piercing* supplied by Dr CARLYLE.

** First written, *mark*.

†† A leaf of the manuscript, containing the fifth stanza, and one half of the sixth, is here lost. The chasm is supplied by Mr MACKENZIE.

" In horrid musings rapt, they fit to mark
 " The labouring moon ; or lift the nightly yell
 " Of that dread spirit, whose gigantic form
 " The feer's entranced eye can well survey,
 " Through the dim air who guides the driving storm,
 " And points the wretched bark its destin'd prey.
 " Or him who hovers, on his flagging wing,
 " O'er the dire whirlpool, that, in ocean's waste,
 " Draws instant down whate'er devoted thing
 " The failing breeze within its reach hath plac'd —
 " The distant seaman hears, and flies with trembling haste.

VI.

" OR, if on land the fiend exerts his fway,
 " Silent he broods o'er quicksand, bog, or fen,
 " Far from the shelt'ring roof and haunts of men,
 " When witch'd darkness shuts the eye of day,
 " And shrouds each star that wont to cheer the night ;
 " Or, if the drifted snow perplex the way,
 " With treach'rous gleam he lures the fated wight,
 " And leads him flound'ring on, and quite astray."
 What though far off, from some dark dell espied
 His glimm'ring mazes cheer th' excursive fight,
 Yet turn, ye wand'ers, turn your steps aside,
 Nor trust the guidance of that faithless light ;
 For watchful, lurking 'mid th' unrustling reed,
 At those mirk * hours the wily monster lies,
 And listens oft to hear the passing steed,
 And frequent round him rolls his fullen eyes,
 If chance his savage wrath may some weak wretch surprise.

VII.

AH, luckless swain, o'er all unblest indeed !
 Whom late bewilder'd in the dank, dark fen,

Far

* First written, *sad*.

Far from his flocks and smoking hamlet then !

To that sad spot " his wayward fate shall lead * :"

On him enrag'd, the fiend, in angry mood,

Shall never look with pity's kind concern,

But instant, furious, raise the whelming flood

O'er its drown'd bank, forbidding all return.

Or, if he meditate his wish'd escape

To some dim hill that seems uprising near,

To his faint eye the grim and grisly shape,

In all its terrors clad, shall wild appear.

Meantime, the wat'ry surge shall round him rise,

Pour'd sudden forth from ev'ry swelling source.

What now remains but tears and hopeless sighs ?

His fear-shook limbs have lost their youthly force,

And down the waves he floats, a pale and breathless corse.

VIII.

For him, in vain, his anxious wife shall wait,

Or wander forth to meet him on his way ;

For him, in vain, at to-fall of the day,

His babes shall linger at th' unclosing † gate.

Ah, ne'er shall he return ! Alone, if night

Her travell'd limbs in broken slumbers steep,

With dropping willows drest, his mournful sprite

Shall visit sad, perchance, her silent sleep :

Then he, perhaps, with moist and wat'ry hand,

Shall fondly seem to press her shudd'ring cheek ‡,

And with his blue swollen face before her stand,

And, shiv'ring cold, these piteous accents speak :

Pursue ||, dear wife, thy daily toils pursue

At dawn or dusk, industrious as before ;

Nor

* A blank in the manuscript. The line filled up by Dr CARLYLE.

† First written, *cottage*.

‡ First written, *Shall seem to press her cold and shudd'ring cheek*.

|| First written, *proceed*.

Nor e'er of me one hapless thought renew,
 While I lie welt'ring on the ozier'd shore,
 Drown'd by the KAELPIE's * wrath, nor e'er shall aid thee more!

IX.

UNBOUNDED is thy range ; with varied stile
 Thy muse may, like those feath'ry tribes which spring
 From their rude rocks, extend her skirting wing
 Round the moist marge of each cold Hebrid isle,
 To that hoar pile which still its ruin shows † :
 In whose small vaults a pigmy-folk is found,
 Whose bones the delver with his spade upthrows,
 And culls them, wond'ring, from the hallow'd ground!
 Or thither where beneath the show'ry west
 The mighty kings of three fair realms are laid ‡ :
 Once foes, perhaps, together now they rest.
 No slaves revere them, and no wars invade :
 Yet frequent now, at midnight's solemn hour,
 The rifted mounds their yawning cells unfold,
 And forth the monarch's stalk with sov'reign pow'r
 In pageant robes, and wreath'd with sheeny gold,
 And on their twilight tombs aerial council hold.

BUT

* A name given in Scotland to a supposed spirit of the waters.

† On the largest of the *Flannan islands* (isles of the Hebrides) are the ruins of a chapel dedicated to St FLANNAN. This is reckoned by the inhabitants of the Western Isles a place of uncommon sanctity. One of the Flannan islands is termed the *Isle of Pigmies* ; and MARTIN says, there have been many small bones dug up here, resembling in miniature those of the human body.

‡ THE island of *Iona* or *Icolmkill*. See MARTIN's Description of the Western Islands of Scotland. That author informs us, that forty-eight kings of Scotland, four kings of Ireland, and five of Norway, were interred in the Church of St OURAN in that island. There were two churches and two monasteries founded there by St COLUMBUS about *A. D.* 565. *BED. Hist. Eccl. l. 3.* COLLINS has taken all his information respecting the Western Isles from MARTIN ; from whom he may likewise have derived his knowledge of the popular superstitions of the Highlanders, with which this ode shows so perfect an acquaintance.

X.

BUT O! o'er all, forget not KILDA's race*,
 On whose bleak rocks, which brave the wafting tides,
 Fair Nature's daughter, Virtue, yet abides.
 Go, just, as they, their blameless manners trace!
 Then to my ear transmit some gentle song
 Of those whose lives are yet sincere and plain,
 Their bounded walks the rugged cliffs along,
 And all their prospect but the wintry main.
 With sparing temp'rance, at the needful time,
 They drain the fainted spring, or, hunger-prest,
 Along th' Atlantic rock undreading climb,
 And of its eggs despoil the Solan's nest.
 Thus blest in primal innocence they live,
 Suffic'd and happy with that frugal fare
 Which tasteful toil and hourly danger give.
 Hard is their shallow soil, and bleak and bare;
 Nor ever vernal bee was heard to murmur there!

XI.

NOR need'st thou blush, that such false themes engage
 Thy gentle mind, of fairer stores posselt;
 For not alone they touch the village breast,
 But fill'd in elder time th' historic page.
 There SHAKESPEARE's self, with ev'ry garland crown'd †,
 In musing hour, his wayward sisters found,
 And with their terrors drest the magic scene.
 From them he fung, when mid his bold design,
 Before the Scot afflicted and aghast,

k

The

* The character of the inhabitants of St Kilda, as here described, agrees perfectly with the accounts given by MARTIN and by MACAULAY, of the people of that island. It is the most westerly of all the Hebrides, and is above 130 miles distant from the main land of Scotland.

† This stanza is more incorrect in its structure than any of the foregoing. There is apparently a line wanting between this and the subsequent one, *In musing hour*, &c. The deficient line ought to have rhymed with *scene*.

The shadowy kings of BANQUO's fated line,
 Through the dark cave in gleamy pageant past.
 Proceed, nor quit the tales which, simply told,
 Could once so well my answ'ring bosom pierce ;
 Proceed, in forceful sounds and colours bold
 The native legends of thy land rehearse ;
 To such adapt thy lyre and suit thy powerful verse.

XII.

In scenes like these, which, daring to depart
 From sober truth, are still to nature true,
 And call forth fresh delight to fancy's view,
 Th' heroic muse employed her TASSO's art !
 How have I trembled, when at TANCRED's stroke,
 Its gushing blood the gaping cypresses pour'd ;
 When each live plant with mortal accents spoke,
 And the wild blast up-heav'd the vanish'd sword * !
 How have I sat, when pip'd the pensive wind,
 To hear his harp, by British FAIRFAX strung.
 Prevailing poet, whose undoubting mind
 Believ'd the magic wonders which he sung !
 Hence at each sound imagination glows ;
 Hence his warm lay with softest sweetness flows ;
 Melting it flows, pure, num'rous, strong and clear,
 And fills th' impassion'd heart, and wins th' harmonious ear †.

ALL

* THESE four lines were originally written thus :

*How have I trembled, when, at TANCRED's side,
 Like him I stalk'd, and all his passions felt ;
 When charm'd by ISMEN, through the forest wide,
 Bark'd in each plant a talking spirit dwelt !*

† THESE lines were originally written thus :

*Hence, sure to charm, his early numbers flow,
 Though strong, yet sweet —————
 Though faithful, sweet ; though strong, of simple kind.
 Hence, with each theme, he bids the bosom glow,
 While his warm lays an easy passage find,
 Pour'd through each inmost nerve, and lull th' harmonious ear.*

XIII.

ALL hail, ye scenes that o'er my soul prevail,
Ye "spacious*" friths and lakes which, far away,
Are by smooth ANNAN fill'd, or past'ral TAY,
Or DON's romantic springs, at distance, hail!
The time shall come when I, perhaps, may tread
Your lowly glens, o'erhung with spreading broom,
Or o'er your stretching heaths by fancy led:
Then will I dress once more the faded bow'r,
Where JOHNSON sat in DRUMMOND's † "social‡" shade,
Or crop from Tiviot's dale each "classic flower,"
And mourn on Yarrow's banks "the widow'd maid||."
Meantime, ye Pow'rs, that on the plains which bore
The cordial youth, on LOTHIAN's plains attend,
Where'er he dwell, on hill, or lowly muir,
To him I lose, your kind protection lend,
And, touch'd with love like mine, preserve my absent friend.

* A blank in the manuscript. The word *spacious* supplied by Dr CARLYLE.

† BEN JOHNSON undertook a journey to Scotland a-foot in 1619, to visit the poet DRUMMOND, at his seat of Hawthornden, near Edinburgh. DRUMMOND has preserved in his works, some very curious heads of their conversation.

‡ A blank in the manuscript. *Social* supplied by Dr CARLYLE.

|| Both these lines left imperfect; supplied by Dr CARLYLE. This last stanza bears more marks of hastiness of composition than any of the rest. Besides the blanks which are supplied by Dr CARLYLE, there is apparently an entire line wanting after the seventh line of the stanza. The deficient line ought to have rhymed with *broom*.

IV. *An ESSAY upon the PRINCIPLES of HISTORICAL COMPOSITION, with an Application of those Principles to the Writings of TACITUS. By JOHN HILL, M. A. F. R. S. EDIN. and Professor of Humanity in the University of EDINBURGH.*

P A R T I.

[*Read by the Author, April 19. 1784.*]

FEW literary exertions put the author's abilities to a severer test than the composition of history. The poet may create a subject for himself, or he may adopt one that is but imperfectly known. In the composition of an epic poem, he instructs and pleases by exhibiting such a train of actions as might have taken place, and, unless he violates probability, his invention may bid defiance to restraint. If his work be imperfect, he has himself to blame, as those very powers which give the form to his subject, gave it first its existence.

THE orator, again, is more closely circumscribed. Not only is his subject known to have existed, but its circumstances, if not witnessed by his hearers, may, for certain, become matters of proof. In spite of every prejudice upon the part of his audience, he professedly takes a side. He is allowed to suppose, that his opponents either are ignorant of certain facts, or are viewing them in a false light. He applies the address of eloquence to their fancy, and the force of argument to their reason; and reckons every stratagem fair by which he can correct the errors that are involuntary, and confute those that are seen.

THE

THE historian is in a situation more trying, in certain respects, than either the poet or the orator. He must unite industry with genius, as by severe labour alone, he has to learn what his subject is. He must make the most of a train of facts too well established to be altered, and the sources of his intelligence are generally open to his readers. Having no prejudice to combat, and no side to support, he can hardly make the weakness of his reader the tool of his address. In the style of his narration, he must exhibit a variety that will suit the meanest, as well as the most splendid actions. Though he is not allowed to fabricate, yet he is required to embellish. His ornaments, by being the genuine, though the best dress of his materials, must fix the reader's attention, without misleading his judgment.

FROM the perception of truth with which historical narration is accompanied, it is of all kinds of writing the most instructive. Men listen more seriously to what they believe, than to the most exquisite fable which fancy can devise. The tale pleases by a temporary conviction of its truth; but though the moral drawn from it be just, yet the impression left behind is easily effaced.

HISTORY then is not only a nice, but a dignified subject of criticism *. It presents to the race which exists, monuments of the wisdom and the weakness of its forefathers. It demands no reverence for its precepts, that is not founded upon a conviction of their propriety. It imparts wisdom, without exposing men to those evils which are its ordinary price; and upon every rock that proved fatal to early adventurers, it leaves a beacon for the security of others.

IN order to establish a canon for judging of the merit of every historical work, we shall try to delineate those qualities which should predominate in the historian's character. Let us
view

* PULCHRUM imprimis videtur, non pati occidere quibus aeternitas debeatur, aliorumque famam cum sua extendere. PLIN. *lib. 5. epist. 8.*

view his mind then in respect to *Feeling*, to *Imagination*, and to *Judgment*; and consider them as the leading powers to which subordinate ones are to be referred. The due union and the due extent of these constitutes that mental temperament, which, by making beauty the vehicle of instruction, must, at once, please the taste and inform the understanding.

It may be thought, perhaps, that, as the three powers mentioned cannot be supposed requisite in the historian alone, so no analysis referring to them can be held truly descriptive of his character. All the fine arts, however, are closely allied. "Habent quoddam commune vinculum (says CICERO), et quasi cognatione quadam inter se continentur." Though the constituents of eminence be the same in the whole, yet these are highly diversified by the applications and the balance required in each. A slight difference in the leading powers of mind forms all the variety which genius in the different arts exhibits. If those principles then that are, at any time, adopted to form a standard for just execution in any one of them be not, in some degree, general, it may be held as certain that they are not found.

By feeling is to be understood that nice sensibility which catches even the slightest impression, and in which there subsists a due proportion between the emotion and the cause of its excitement. Those characters of feeling that are adverse to just execution in the works of taste arise both from its deficiency and its excess. In the one case, nature has done too little, in the other she has done too much. That callousness which proceeds from the want of feeling excludes impressions of which others are conscious, and those false irritations which proceed from its excess suggest emotions which, by the sober, are deemed unnatural, because they were never felt by them. It is in that just medium, which is equally removed from the extremes mentioned, that feeling becomes the instrument of genius. The masterly execution of an able writer pleases and even improves
that

that taste, in which the balance is not delicate; and the enjoyment of the reader is jointly proportioned to the absolute justness of the author's feelings, and to the correspondence between them and his own.

By perceptions thus delicate, the historian's character must be highly improved. His descriptions must be tender, as being founded on those nice circumstances that escape an ordinary eye; and though his sensibility must multiply the grounds of description, yet the correctness of his feeling leads him to such only as are just. Historical narration is more frequently faulty from that bluntness of perception, by which the minute qualities of objects are concealed, than from that defect in judgment, by which the least proper are selected. The detail often becomes prolix from the dulness of the writer. One of true feeling adopts a concise energy, which reaches both the heart and the understanding. He permits his reader to pass little that is worthy of his notice, and he with-holds it from that only which is really beneath it.

FROM an historian of this description a delicate sense of what he owes to himself and to his reader is expected. If the strain of his narration ceases, at any time, to be dignified, it is to remove, by variety, what would otherwise become tiresome. Quaint ornaments in his style he rejects as deformities. To the approbation of the judicious, he cannot be supposed indifferent; but he scorns those condescensions with which the herd of readers is pleased*. A remark that is obvious and common finds no place in his narration; and, from a sense of personal dignity, he would rather leave the more ignorant uninformed, than disgust the discerning. His sensibility to every moral sentiment, not only detects the least symptom of what is good or bad in human conduct, but is accompanied with an immediate approbation of the one and abhorrence of the other. He re-
cords

* INTELLIGES actum hoc, ut tu scires quid illi placeret, non ut ille placeret tibi.
SEN. Ep. 100.

cords the truth as he finds it, without magnifying the virtues of his friend, or extenuating those of his enemy.

Though POLYBIUS repeatedly compares that history in which a due regard has not been paid to truth, to an animal without eyes, yet the comparison does, in reality, suggest less than may be affirmed *. An historian without fidelity is worse than useless; he is injurious to mankind. Upon the credit of his narration, the happiness of future generations may rest. By an error in point of fact, every philosopher may be mortified with circumstances, which, by confuting his theory, limit his usefulness, and impair his fame. In such cases, however, the evil is personal. If society remains unenlightened, it remains also unhurt; while, by an error in the history of men, oppressive establishments may be formed, and the happiness of nations destroyed.

Just feeling, then, in the mind of an historian is the basis of many excellencies. By means of it, his descriptions become delicate, his narration interesting, his manner dignified, and his fidelity unquestionable.

BUT, besides an acute and judicious sense of things that exist, a lively apprehension of such as are ideal is required of an historian. The intimations of feeling carry along with them a belief of the reality of their objects, while the suggestions of fancy are accompanied with no such sentiment. If judgment is required to correct that sensibility which would otherwise become feverish, it is fully as needful, to correct that vigour of imagination, which would end in extravagance.

FROM the severity of those attentions to truth, which no good historian can sacrifice, it may be understood, perhaps, that imagination is a power, which he ought rarely, if at all, to exert. This, however, is not the case. Imagination may be a dangerous

* Ότι καθάπερ ἐν ψυχῇ σώματος τῶν ὀφείων ἐξαίρεθις αὐτῶν ἀχρησταί το ὅλον, ὅτως ἐξ ἱστορίας ἐὰν ἀφῇς τὴν ἀληθειάν, τὸ κατὰλειπομένον αὐτῆς ἀνωφελες γινώσκει διηγημα.

rous instrument in the hands of the unwary, but it is a powerful one in the hands of the judicious. He who relates those great transactions, in which the passions of men have been interested, must enter into the scenes which he describes, and must speak the language of those who bore a part in them. A cold narrative that is literally true would often be a false picture. Expression, besides, is as susceptible of modifications as the sentiment to which it gives vent. During the influence of passion, figurative language indicates the degree of emotion excited in the speaker, and stimulates the hearer's feelings till they accord with his own. Even the illiterate suffer no delusion by that play of fancy which gives energy to speech. They, as well as the learned, instinctively strip the animated conception of what is adventitious, and interpret meaning with the most precise exactness.

ALTHOUGH the historian, by the exertions of his fancy, may often introduce ornament with advantage, yet he must beware of employing it to excess. An impertinent profusion of beauties tallies not with that dignity of manner which he should assume and maintain. It is either the sign of that flippant character, which is beneath him, or it is the resource of one, conscious of his own coldness, and borrowing from art the signs of that animation which nature has denied him.

BUT imagination is of use to the historian, not only when he is heated with his subject, and thereby led to adopt figurative language, but also when he means to describe. The vivacity of those conceptions which he is able to excite in others may equal, but will never surpass the vivacity of his own. By means of fancy, he can seize the circumstance most characteristic of each object. From a just consciousness of the laws of association in his own mind, he discovers what these should be in those of others who have an equally correct taste. By laying hold of one or a few circumstances wisely, he may produce a very powerful effect. He may give existence to animated description, instead of a lifeless, because a verbose detail.

THIS double use of imagination in the composition of history is perfectly consistent with the definition at first given of that power. There is always reality in the emotion excited by figurative language; but, at some times, there is none in the subject of it, and, at other times, the qualities of that subject are not perceived precisely as they exist. A description, too, if rigidly interpreted according to the letter, would be virtually destroyed. Principles strictly logical are not to be applied to terms denoting an exertion of fancy; because they carry along with them more or less latitude, according to the intention of the speaker at the time. The aggregate of these terms suggests somewhat different from that which it naturally excites. It only begins the picture which the fancy of the hearer must complete, and leaves that task to be performed by this delicate faculty, for which the powers of expression simply are unfit.

By a fine imagination, then, the historian's language acquires energy, and his descriptions liveliness. The power may improve his expression (we have found) without adulterating his matter. It may, in some instances, be too strong, and, in others, too weak. In either case, the feelings of the writer and the reader may be in unison, without hitting their due pitch; and the high purposes of language, as the instrument of nice interpretation, must be thereby defeated.

IN the account already given of the powers of feeling and imagination, a reference has been made to another one, whose province it is to control the excesses of both. When the two former are feeble, the person in whom this is the case, must, for ever, keep the rank which nature has assigned him. No provision is made for multiplying the avenues by which perceptions can enter his mind, nor for increasing his power of forming ideal combinations of such as do. By means of judgment, however, luxuriance may be corrected, though deficiency cannot be supplied; and such a balance may be established among the different powers, as will constitute the perfection of each.

JUDGMENT

JUDGMENT stands opposed to feeling, as the operations of the latter are prior in the order of nature; the one passing sentence upon perceptions, which the other has previously furnished. It stands opposed to imagination, as there is belief in the reality both of the subject and the decision. Different, nay opposite judgments may be formed of one thing; but, if simple apprehensions be different, their subject cannot be the same.

TRUE judgment enables men to discern both the truth of propositions fairly stated, and the propriety of sentiment and conduct in every particular instance. As the historian's judgment is proved, not only by his reflections on the conduct of others, but by what he does himself; so the first indication of the degree in which he possesses this power is to be seen in his choice of a subject. The rule in HORACE is alike applicable to writers of every kind:

— *Verfate diu, quid ferre recusent,
Quid valeant humeri* *.

Real abilities are generally accompanied with a just notion of their extent. This consciousness, at the same time, renders neither the possessor presumptuous, nor the observer jealous. True discernment destroys every thing like arrogance in the former; and, where there is a clear superiority, men repine not at that subordination in talents which nature herself has established.

ALTHOUGH the highest abilities will make the most of all historical subjects, yet, among these, there is such a difference as to give room for a judicious choice. Ordinary genius would be foiled where the most distinguished can best shew itself. The difficulty of historical subjects depends upon the state of the facts to be recorded. When these are of very ancient or of very recent date, it tries the historian's judgment, upon the one hand, to distinguish the spurious from the genuine, and to make the most of information that is perhaps but scanty; and, upon the other, to shun the odium of parties, without neglect-

* HOR. de Arte Poëtica, v. 39.

ing what he owes to himself*. He must possess the subtilty of the politician, whose transactions he relates, so as to perceive the intricacies of his character, and the most latent motives of his conduct. If he does, he will draw the picture with exactness; if he does not, he must mislead posterity, for whose benefit chiefly he professes to write.

THE judgment exhibited in the choice of a subject may be held a security for the distinct arrangement of all its parts.

—— ——— *Cui lecta potenter erit res,
Nec facundia deferet hunc, nec lucidus ordo.*

When the historian exhibits events that took place nearly at the same time in different places, the distinctness of his detail must become manifest as these multiply, and the difficulty of maintaining a due unity in his subject is thereby increased. The disjointed record of a journalist deserves not the appellation of history. That unity mentioned, too, is alike necessary, whether the subject be a single transaction in one state, (such as CATILINE'S conspiracy), or the continued transactions of a nation.

THOUGH the censure of DIONYSIUS of Halicarnassus upon THUCYDIDES be severe, it is not without foundation. In the opinion of that great critic, the attention of the historian cannot be too much turned to this, τὸ τεχνικώτερον μέρος, the nice œconomy and division of his subject. For the want of due order, no compensation can be made, and every arrangement that breaks the detail improperly, defeats the purpose of all arrangement, which is perspicuity. The train of events recorded should be precisely that which took place; and the connection between
causes

* Tu tamen jam nunc cogita, quæ potissimum tempora aggrediar. Vetera et scripta aliis? parata inquisitio sed onerosa collatio: Intacta et nova? graves offensæ, levis gratia. Nam præter id, quod in tantis vitiis hominum plura culpanda sunt, quam laudanda, tum si laudaveris, parcus: Si culpaveris, nimius fuisse dicaris: Quamvis illud plenissime, hoc restrictissime feceris. PLIN. lib. 5. ep. 8.

causes and effects as discernible in the history as it before was in the scenes to which it refers. An historian's business, according to LUCIAN, is to relate things as they were done *. The reader's experience is thus increased, as if he had been actually engaged in the affairs which he contemplates, and he becomes prepared for occurrences by which he would have been otherwise embarrassed †.

THE historian's impartiality, which is a quality of the highest importance, is always proportioned to the strength of his judgment. Fidelity and impartiality are sometimes confounded, though the one is an attribute of the heart, and the other of the understanding. An historian of fidelity never means to deceive; an historian that is impartial is not apt to be deceived by circumstances that relate either remotely or immediately to himself. In the relations of the former, we look for what is strictly true; in those of the latter, for such a state of facts as exhibits no prejudices into which we and others are unable to enter. We condemn the want of fidelity, as leading to a designed violation of truth; but we pity the weakness that would mislead involuntarily, and is biassed by circumstances that are purely personal. LUCIAN requires of the historian to divest himself of every possible ground of partiality; "to have the indifference of a stranger in judging of his own works; to be of no state; to form his own laws; to acknowledge no king, and to speak the truth without regard to the opinion of parties ‡."

BUT judgment not only divests the historian of any unjustifiable attachment to what concerns himself, but enables him to see even indifferent objects in their true light. By means of this, he is disposed neither to depreciate what is really important, nor to over-rate what is really mean. In examining the probability

* Τα δὲ Συγγραφικὰ ἔργα ἐν, ὡς ἐπὶ ἀρχῇ εἰπείν.

† OCCASIONES autem redeunt in orbem, et quod olim erat commodum rursus adhiberi et prodesse potest. BACON *de Aug. Scient. lib. 2. c. 12.*

‡ Ξένος ἐν τοῖς βίβλοις, καὶ ἀπολις, αὐτονομός, ἀβασιλευτός, ὅτι τὰ δὲ ἡ τὰ δὲ δοξῇ λογιζόμενος, ἀλλὰ τι πεπρακται λέγων. Πῶς δὲ ἴσως. συγγρ.

bility of dubious events, he is not so credulous as to acquiesce in slight evidence, nor does he stubbornly reject such as should convince him. His mind, like a faithful mirror, reflects every thing precisely as it is seen. As his facts are genuine, so his observations will be pertinent. Knowing, also, that men refuse the praise that is too eagerly courted, he will introduce his own remarks with caution, and will chuse rather to surprise with depth in the body of his detail, than to disappoint expectations that he had formally summoned. My Lord BACON's observation upon this part of the character of an historian is judicious and happily expressed: "*Licet enim historia quæque prudentior*" "*politicis præceptis et monitis veluti impregnata sit, tamen*" "*scriptor ipse sibi obstetricari non debet* *."

JUDGMENT, then, in the mind of an historian, besides giving the other powers their due value, is itself the foundation of many capital qualities. It enables him to chuse and to arrange his subject, so as to do most justice to his own abilities, and to give most instruction to his reader. It secures the fairness of his decisions, in spite of those personal connections with which most men are blinded. It supposes sagacity in his opinions as to past things that are doubtful, and future things that are contingent. While it makes him view objects as they are, and secures his reader against the impertinence of observations that are either trifling or misplaced, it represses the weak vanity that lessens the merit which it means to exaggerate.

To one or other of the three powers, of feeling, of imagination, or of judgment, (it should seem), all the qualities of a great historian are to be referred. Industry and preliminary information have been allowed to be necessary; but these tend only to do justice to those primary powers. Nothing has been said as to the principle of taste; because, according to the observation of the ingenious author of *The essay upon the sublime and beautiful*, this is, in reality, no distinct power, but is the result of the whole of the powers specified when combined.

The

* BACON de Aug. Scient. l. 2. c. 10.

The characters of an author's style, too, are fixed by those of his mind. It is delicate, lively and accurate, according to his sensibility, his fancy, and his judgment; and its comparative excellence is determined by the absolute strength of each power, and the general balance that subsists among the whole.

AFTER attempting to establish a standard, by which the merit of any historical work is to be tried, I mean now to apply it particularly to the writings of TACITUS. In doing so, I propose to give examples that will indicate the strength of the three powers stated, taken separately, and in the order in which they have been defined. After contemplating certain instances, in which our author's superiority, with respect to each, will be evident, others may perhaps be suggested, in which his greatest admirers cannot free him from censure.

THOUGH it is difficult to determine which of the three powers mentioned predominated in the mind of TACITUS; yet, from the nature of his subjects, his sensibility was often exercised in an uncommon degree. Instances of this are so numerous, that we must select a few only of the most striking. Let us take that of the death of GERMANICUS, and of the state of his widow AGRIPPINA, in the end of the second and beginning of the third book of the Annals.

THE situation of GERMANICUS, just before his death, (it must be remembered), was singular. He had long been the favourite of the Romans, on account of the agreeableness of his manners, and the high military character that he had acquired at a very early period of life. He was the adopted son of TIBERIUS, who, having become jealous of his popularity, had called him from the conquest of Germany, which he had nearly completed. He was dismissed from Rome, under pretence of settling certain differences in the east. His conduct there was invidiously watched by PISO, the governor of Syria, who was in the emperor's confidence. He was certain, when upon his death-bed, that he had been poisoned by PISO; and, while he complains

plaints of the hardness of his fate, he conjures the friends who stood around him to avenge his injuries. "Non hoc præcipuum amicorum munus est, prosequi defunctum ignavo questu; sed quæ voluerit meminisse, quæ mandaverit exsequi. Flebunt GERMANICUM etiam ignoti: vindicabitis vos, si me potius quam fortunam meam fovebatis. Ostendite populo Romano Divi AUGUSTI neptem, eandemque conjugem meam: numerate sex liberos. Misericordia cum accusantibus erit: Fingentibusque scelestæ mandata, aut non credent homines, aut non ignoscent."

OUR author's description is not less delicate in the case of AGRIPPINA going on board a ship for Rome, surrounded with her children, and carrying the ashes of her husband. The sight of this seems to have affected the spectators deeply, and the description is not less moving than the spectacle. "Miserantibus cunctis quod femina nobilitate princeps pulcherrimo modo matrimonio inter venerantis gratantisque aspici solita, tunc feralis reliquias sinu ferret, incerta ultionis, anxia sui et infelici fecunditate fortunæ toties obnoxia." This last circumstance is very happily laid hold of. The number of AGRIPPINA's children, which was once a blessing, had now become a curse. It only enlarged the mark at which the father of her husband was to direct his malice.

UPON her approach to the coast of Italy, another scene presents itself, equally affecting, from the unfeigned sympathy of the spectators, and the deep grief of AGRIPPINA herself. "Atque ubi primum ex alto visa classis, complentur non modo portus et proxima maris, sed mœnia, ac tecta, quaque longissime prospectari poterat, mœrentium turba, et rogantium inter se, "Silentione an voce aliqua egredientem exciperent." Neque fatis constabat quid pro tempore foret: Cum classis paulatim successit, non alacri ut adsolet remigio; sed cunctis ad tristitiam compositis. Postquam duobus cum liberis feralem urnam tenens egressa navi, defixit oculos; idem
"omnium

“ omnium gemitus, neque discerneres proximos, alienos, viro-
 “ rum feminarumve planctus: Nisi quod comitatum AGRIPPINÆ
 “ longo mœrore fessum, obvii et recentes in dolore anteibant.”

THE death of OTHO, in the 48th chapter of the second book of the history, presents another scene, in which the delicacy of our author's feelings is manifest. In both cases, by a previous narration, in which the art of the writer is judiciously concealed, he prepares the reader completely for those strokes in which his genius is to break forth. OTHO, after the defeat of his army, is represented as despairing of future success, and as having formed the resolution of putting an end to his existence. He announces this resolution to his friends, with such art, as at once to maintain his own dignity, and to move their compassion. He reproves his nephew SALVIUS COCCEIANUS for dreading the vengeance of VITELLIUS, upon whose generosity (he thought) he might throw himself with confidence; and finishes his advice thus: “ Proinde erecto animo capefferet vitam, neu
 “ patrum sibi OTHONEM fuisse, aut oblivisceretur unquam, aut
 “ nimium meminisset.”

THE exhortation of ÆNEAS to his son ASCANIUS has been much admired:

*Et te animo repetentem exempla tuorum,
 Et pater ÆNEAS et avunculus excitet* HECTOR*.

IN point of delicacy, in a similar situation however, the historian has got beyond the poet. By the use of the adverb *nimium*, OTHO not only suggests to COCCEIANUS what the world would expect from him as his relation, but delicately insinuates, that the remembrance of the uncle's virtues would furnish no apology for the nephew's defects.

THE strength of feeling exhibited by TACITUS always keeps pace with the trying circumstances in which his characters are placed. Of this we have a striking example in the account given of the trial of SORANUS and his daughter SERVILIA, in
 the

* VIRG. ÆN. xii. 439.

the 30th chapter of the 16th book of the Annals. During the many unjust prosecutions under NERO, SORANUS was accused of intimacy with RUBELLIUS PLAUTUS, who had been banished, and also of misbehaviour as a proconsul. His daughter, from strong affection to her injured father, had sold her clothes and jewels, in order to consult the magicians as to the event of his trial. On this account, she, too, was ordered to appear before the senate. "Igitur accita est in senatum, steteruntque diversi ante tribunal consulum, grandis ævo parens; contra filia intra vicesimum ætatis annum, nuper marito ANNIO POLLIONE in exilium pulso, viduata desolataque: Ac ne patrem quidem intuens, cujus onerasse pericula videbatur. Tum interrogante accusatore, an cultus dotales, an detractum cervici monile venum dedisset quo pecuniam faciendis magicis sacris contraheret? Primum strata humi, longoque fletu et silentio, post altaria et aram complexa; "Nullos, inquit, impios deos, nullas devotiones, nec aliud infelicibus precibus invocavi, quam ut hunc optimum patrem, tu CÆSAR, et vos Patres fervaretis incolumem. Sic gemmas et vestes et dignitatis insignia dedi, quomodo si sanguinem et vitam poposcissent. Viderint isti, antehac mihi ignoti, quo nomine sint, quas artes exercent: Nulla mihi principis mentio, nisi inter numina fuit. Nescit tamen miserrimus pater: Et si crimen est, sola deliqui." Loquentis adhuc verba excipit SORANUS proclamatque, "Non illam in provinciam secum profectam, non PLAUTO per ætatem nosci potuisse; non criminibus mariti connexam; nimiam tantum pietatis ream, separarent a se quamcunque sortem subiret." Simul in amplexus occurrentis filiae ruebat, nisi interjecti lictores utrisque obstitissent."

A BEAUTIFUL contest is here presented between the strongest parental and filial attachments. The description is the language of nature throughout. Every circumstance is carried its due length, without bordering upon extravagance. No tragic poet, whose fancy is allowed a latitude which is denied the historian,

storian, could exhibit even the scene he had created, with more exquisite delicacy than TACITUS describes this that had actually taken place.

BUT the fine feeling of our author is apparent, not only upon such gloomy and such trying occasions as those mentioned, but in the more ordinary transactions of life. When HORTALUS, a descendant of the great HORTENSIVS, applied to the senate, as mentioned in the 38th chapter of the 2d book of the Annals, for an allowance to enable him to rear that family, which, at the command of AUGUSTUS, he had procreated, even the servile senators were shocked with TIBERIUS's refusal. The emperor perceiving this, agreed to give a paltry donative to his male children. Some of the senators indeed expressed their thankfulness; but HORTALUS was silent. "Egere alii grates; filius HORTALUS, pavore, an avitæ nobilitatis etiam inter angustias fortunæ retinens." This last conjecture, as to the cause of HORTALUS's silence, could be formed only by a person delicately sensible of what was due to himself. More than sufficient violence had been done to the feelings of HORTALUS, when he confessed his poverty and begged relief. The niggardly behaviour of TIBERIUS gave him a right to insult the emperor, and, by an expressive silence, to tell him, in the face of his senate, that though he had been forced to implore his bounty, yet he despised his character.

That TACITUS was a strictly moral writer, and expressed, at all times, the strongest love of virtue and detestation of vice, is evident throughout his works. A sense of his duty as an historian seems often to have forced him to relate what he would have wished to conceal. He appears to feel for those miseries of others, which, as a rigid moralist, he allows to be the just consequence of their vices. In the 6th chapter of the 6th book of his Annals, he describes TIBERIUS as completely wretched, and agrees with SOCRATES as to the cause of this unhappiness.

"Neque frustra præstantissimus sapientiæ firmare solitus est, si

“recludantur tyrannorum mentes, posse aspici laniatus et ictus;
 “quando ut corpora verberibus, ita sævitia, libidine, malis con-
 “fultis animus dilaceretur. Quippe TIBERIUM, non fortuna
 “non solitudines protegebant, quin tormenta pectoris suasque
 “ipse pœnas fateretur.”

THE high independence of spirit possessed by TACITUS, may be inferred from what he says both of himself and of others. In the 63d chapter of the 2d book of the Annals, he condemns MAROBODUUS for continuing in existence as the prisoner of TIBERIUS. “Consenuitque multum imminuta claritate, ob
 “nimiam vivendi cupidinem.”

THIS same independent spirit is sometimes seen conjoined with his love of truth. As the reign of NERO was not very distant from the times in which he wrote, of course, by attacking the servility of the senate, he must have offended many people of the first rank. Their displeasure, however, he despised, when put in competition with his own honour and veracity. “Neque tamen filebimus, si quod senatusconsultum adulatione
 “novum aut patientia extremum fuit*.”

FROM the instances quoted, it appears, that TACITUS possessed, in no ordinary degree, those qualities of an historian, that are dependent upon feeling. Few circumstances, from their minuteness, could escape his observation. He felt strongly the finest emotions, which the most trying situations of his characters could excite. He was, at all times, the friend of virtue. A regard for posterity seems chiefly to have prompted him to exert his powers as an historian; and, from the same benevolent principle, he is always scrupulously careful, not to affirm with certainty when there could be the least reason for doubt.

THE power of imagination, as we observed, enables the historian to write with energy, by the proper use of figurative language, and to select those figures that are the fittest for description. Upon examining the style of TACITUS attentively, it will

* Ann. l. 4. c. 64.

will appear, that he uses figures more sparingly than is commonly imagined. Though the general train of his narrative be nervous, yet few parts of it are highly embellished. The figures that he employs are used more frequently with a design to explain his idea, than to announce the strength of his emotion ; and even when he has this last purpose in view, he often employs interrogations, and such other modes of speech, as are the ordinary language of passion.

FROM the justness of TACITUS's discernment, his similes are remarkably happy. They are, indeed, rarely, but they are always judiciously introduced. It is, in every instance, clear, that he had perceived the resemblance strongly and distinctly himself ; and, by making the allusion, some good purpose is completely served. Thus, to give a lively idea of the torpid indolence of VITELLIUS, in the 36th chapter of the 3d book of his History, he compares him to those lazy animals, which, when the calls of nature are satisfied, have no other object of desire. " Sed umbra-
" braculis hortorum abditus, ut ignava animalia, quibus si ci-
" bum fuggeras jacent torpentque ; præterita, instantia, futura
" pari oblivione dimiserat." The expression in the end of this sentence is both bold and happy. The term *dimiserat* intimates a kind of activity even in the indulgence of sloth ; and the term *oblivio*, applied to the present and the future, insinuates, that both perception and foresight were extinguished, like the impressions of memory when effaced.

ONE of the boldest, and, at the same time, one of the happiest figures to be found in TACITUS, is that at the end of his life of AGRICOLA. It is, at once, an instance of the prosopopeia and the apostrophe, as it supposes life in his father-in-law who was dead, and gives presence to a person who was absent. The high respect entertained for the memory, and the deep grief felt for the death of AGRICOLA, justified the use of these bold figures ; and, as they are introduced with propriety, so they are supported with the utmost art. " Tu vero felix
" AGRICOLA.

“ AGRICOLA non vitæ tantum claritate, sed etiam opportunita-
 “ te mortis. Ut perhibent qui interfuerunt novissimis sermo-
 “ nibus tuis, constans et libens fatum excepisti, tanquam pro
 “ virili portione innocentiam principi donares. Sed mihi filiæ-
 “ que præter acerbitatem parentis erepti, auget mœstitiam, quod
 “ assidere valetudini, fovere deficientem, fatiari vultu, complexu,
 “ non contigit. Excepissemus certe mandata vocesque, quas
 “ penitus animo figeremus. Noster hic dolor, nostrum vulnus :
 “ Nobis tam longæ absentiæ conditione ante quadriennium
 “ amissus es. Omnia sine dubio, optime parentum, assidente
 “ amantissima uxore, superfuere honori tuo : Paucioribus tamen
 “ lacrymis compositus es, et novissima in luce desideravere ali-
 “ quid oculi tui.”

THE delicacy, joined to the strength of painting, which is discernible in the passage now quoted, shows sufficiently, that though TACITUS employs figures seldom, yet his doing so arises from no defect in his powers. The frequent use of these is, in fact, a stratagem to which writers of ordinary genius feel themselves driven. They wish to borrow a device from art, to conquer a barrier established by nature. For a device of this kind, TACITUS had no occasion. The ordinary train of his narration is sufficiently animated to summon and to retain his reader's attention ; and, when he chuses to leave this train, he knows perfectly how to rise with propriety, and to descend without falling.

THE instances of fine description are so numerous in TACITUS, that it is not easy to determine which ought to be selected. In all his attempts to describe, brevity is studied. When he describes the plague at Rome, in the 13th chapter of the 16th book of his Annals, he employs a few sentences, but each sentence is full of meaning. “ Omne mortaliū genus
 “ vis pestilentiaē depopulabatur, nulla cæli intemperie quæ oc-
 “ curreret oculis. Sed domus corporibus exanimis, itinera fu-
 “ neribus complebantur. Non sexus, non ætas periculo vacua.
 “ Servitia

“ Servitia perinde ac ingenua plebes raptim extingui, inter con-
 “ jugum et liberorum lamenta, qui dum affident, dum deflent,
 “ sæpe eodem rogo cremabantur. Equitum senatorumque inte-
 “ ritus, quamvis promiscui, minus flebiles erant, tanquam com-
 “ muni mortalitate, sævitiam principis prævenirent.”

THIS description we must own to be inferior to that of the plague at Athens by THUCYDIDES. But the Greek historian (it must be remembered) had suffered from the disease himself; had seen its direful effects, combined with those of war; and had resolved to enumerate its symptoms, for the benefit of posterity, in the course of six chapters. TACITUS means to relate only what he had heard. He does not seem to have copied THUCYDIDES; though he, too, mentions, that numbers of carcases lay neglected in private houses, upon the streets, at the sides of fountains, and in the temples. “Ο φόρος ἐγίγνετο πένι κοσμῷ,

“ ἀλλὰ καὶ νεκροὶ ἐπ' ἀλλήλοις ἀποθνήσκοντες ἐκείντο. καὶ ἐν ταῖς ὁδοῖς ἐκυλινδούντο καὶ
 “ περὶ τὰς κρήνας ἀπασας ἡμιθνήτες τῇ τε ὕδατος ἐπιθυμίᾳ. τὰ τε ἱερά ἐν οἷς ἐσκήνυν-
 “ το νεκρῶν πλεῖα ἦν, αὐτὲς εὐαποθνήσκοντων *.”

LUCRETIVS, in the description he gives of the plague at the end of his sixth book, has copied THUCYDIDES closely, but seems to have come short of the simplicity and masterly elegance of the historian.

THE situation of OCTAVIA, after her divorce from NERO, forms one of the most highly finished descriptions in the writings of TACITUS. After the tyrant had espoused POPPÆA, under the appearance of gratifying the wishes of his people, whose resentment he in fact dreaded, he took back his injured wife. By the arts of POPPÆA, however, which were skilfully directed against his weaknesses, he dismissed OCTAVIA again, and bribed one of his minions, to screen his injustice, by declaring that she had been guilty with him. Upon this, the innocent OCTAVIA was banished to the island of Pandateria, and the sentiments of the spectators upon this undeserved severity, are the ground of the description mentioned. “ Non alia exsul vifem-

“ tium

* Οὐκυνδ. το δευτ. κεφ. νι.

“tium oculos majore misericordia affecit. Meminerant adhuc
 “quidam AGRIPPINÆ, a TIBERIO, recentior JULIÆ memoria
 “obversabatur, a CLAUDIO pulsæ. Sed illis robur ætatis af-
 “fuerat. Læta aliqua viderant, et præsentem sævitiam me-
 “lioris olim fortunæ recordatione allevabant. Huic primus
 “nuptiarum dies loco funeris fuit, deductæ in domum, in qua
 “nihil nisi luctuosum haberet, erepto per venenum patre, et
 “statim fratre. Tum ancilla domina validior. Et POPPÆA
 “non nisi in perniciem uxoris nupta. Postremo crimen omni
 “exitio gravius *.”

THIS description is as artful in fact, as it is artless in appearance. The circumstances said to move the compassion of the spectators, are marked with wonderful judgment; and the beautiful climax exhibited in the arrangement of them, produces a very uncommon effect. Their feelings first rest upon the difference between the situation of OCTAVIA, and that of other women of distinction who had been subjected to the like fate. They next rest upon her personal disgrace, as an empress, becoming subject to a servant; next upon the immediate destruction threatened her by this marriage of POPPÆA; and last of all, upon the false accusation of having been unfaithful to her husband, and guilty with a miscreant, which no form of destruction could equal. The conditions upon which the fancy operates successfully are here fulfilled. It has full room to work, and its exertions are not clogged by an unmeaning verbosity.

FROM fulfilling the conditions now mentioned, THUCYDIDES has acquired immortal honour by his description of the retreat of the Athenian army, in the 7th book of his History. The barbarity of the conquerors and the distress of the vanquished appear equally incredible, though a few circumstances only are employed to suggest these. During the passage of the Athenians over the river Aspinarus, from the extremity of fa-
 tigue

* Ann. l. 14. c. 63.

tigue and of thirst, they seem driven to a kind of frantic despair. Though the stream in which they then stood was polluted with mud, and with the blood of their countrymen, yet they are represented as fighting about the water in this corrupted state. “*καὶ τὸ ὕδωρ εὐθὺς διεφθάρτο· ἀλλ’ ἔθεν ἥσαν ἐπινετο τε ὁμοῦ τῷ πηλῷ ἡμάτωμα·*”
 “*ὄν καὶ περιμαχέτον ἦν τοῖς πολλοῖς **.”

TACITUS paints, in the most lively colours, the distress of VITELLIUS upon the success of the Flavian party, and the distracted state of his mind upon returning to his palace, which he had before left, and then found deserted. “*Dein mobilitate ingenii, et quæ natura pavoris est, cum omnia metuenti præsentia maxime displicerent, in palatium regreditur, vastum desertumque; dilapsis etiam infimis servitiorum, aut occursum ejus declinantibus. Terret solitudo, et tacentes loci; tentat clausa; inhorrescit vacuis: Fessusque misero errore, et pudenda latebra semet occultans, ab JULIO PLACIDO tribuno cohortis, protrahitur. Vincæ pone tergum manus, laniata veste, fœdum spectaculum ducebatur, multis increpantibus, nullo illacrymante. Deformitas exitus misericordiam abstulerat.†.*”

BUT the uncommon talent for description possessed by TACITUS, is often manifest from his judicious selection of a single anecdote, as explanatory of character. Of this we have a remarkable instance in the 35th chapter of the 1st book of the History. When the old emperor GALBA was still sitting in his palace, and hearing expressions of loyalty, which, after the success of OTHO, he suspected to be insincere, one JULIUS ATTICUS comes up to him, declaring that he had slain the usurper with the bloody dagger which he then held in his hand. The emperor's reply was such as could hardly have been expected. “*Commilito, inquit, quis jussit?*” This single anecdote is so completely characteristic, as almost to supersede the necessity of the judicious comment that follows: “*Insigni animo ad coercendam militarem licen-*

“*tiam,*

* *Θουκυδ. το ἐξδ. κίφ. πδ.*

† *Hist. l. 3. c. 85.*

“ tiam, minantibus intrepidus, adversus blandientes incorruptus.”

IN point of imagination, then, the genius of TACITUS is by no means deficient. Though he uses figurative language sparingly, yet he is highly successful when he does. Many of his descriptions may be held perfect in their kind, and will bear a comparison with those of the most distinguished historians of Greece. In all of them brevity is studied, and striking circumstances judiciously seized. These are held forth to the reader with such art, as neither to check the operations of his fancy, by suggesting too extensive a subject, nor to stop those operations completely, by suggesting one that is too narrow.

IN the sequel of this paper, I shall produce some proofs of that soundness of judgment in TACITUS, which is the distinguishing quality of a great historian. I shall afterwards point out his supposed faults, in certain respects, by an application of that criterion which may have evinced his merits in others; and shall try to mark particular deviations in his style, from that pure standard which was exhibited during the Augustan age*.

* SEE the Second Part of this Paper afterwards.

V. *On the DRAMATIC or ANCIENT FORM of HISTORICAL COMPOSITION.* By WILLIAM RICHARDSON, M. A. F. R. S. EDIN. and Professor of Humanity in the University of GLASGOW.

[Read by Mr FRASER TYTLER, Secretary, June 21. 1784.]

IN comparing ancient with modern historians, we meet with one remarkable circumstance in which they differ. The ancient historians are dramatic, the modern narrative. The ancients exhibit eminent persons delivering long speeches, adorned, as the occasion may require, with all the graces and force of eloquence. This is seldom done by the moderns. If it is ever necessary to give an account of what may have been delivered on an interesting subject by an eminent speaker, they tell us, excepting in such works as may be accounted translations, or in such histories, as those of BUCHANAN and GUICCIARDINI, written manifestly after the models of antiquity, *That* he made use of such or such arguments; and, adhering strictly to the narrative form, they never venture on the bolder task of displaying him in his own person, delivering a long oration.

I. It is probable, however, that the earliest ancient historians were not induced to a practice so peculiar to themselves by critical considerations. They adopted it without any reasoning about its advantages. They could state no comparison between it and any other form of historical composition. They knew no other, and were led to it, both in its beginnings and continuation, by the particular situation and circumstances in which they were placed. This may be illustrated by a few remarks.

The earliest historians were mere narrators of facts. They were not very anxious either about investigating causes or tracing effects. If they were desirous of instructing their readers or hearers, (for the earliest histories were often recited to a numerous audience), they were no less desirous of amusing them. In such compositions, therefore, they were led to imitate conversation. Their histories were, in truth, no other than oral narratives and stories committed to writing. But, in conversation, the narrator of an interesting story becomes animated in his narrative; and if, like the ancient Greeks, he possess sensibility, the spirit exhibited in his story will be proportioned to the vivacity of his feelings. Lively feelings, however, lead persons, in relating or describing the actions or conduct of others, to become dramatic; that is, to tell us the very words or sayings of the person they describe; and not only so, but to recite them as if he himself were the speaker. Now this animated mode is imitated by the earliest writers who describe human actions. They do so at first, because it is done in conversation; they continue the practice, because it is lively and interesting. As, in conversation, the speeches or sayings attributed to the person whose conduct was delineated, were short; they were also short in the earliest, and perhaps most agreeable form of written history. Of this the sacred historians and HERODOTUS afford us sufficient proof. It was not till after historical composition had been some time in use, that it presented to us long speeches and elaborate declamation. Its earliest species, therefore, may be termed colloquial, as distinguished from that which, belonging to the class of dramatic history, followed soon after, and may be termed oratorical. Perhaps there was an intermediate step. Poets were earlier than historians; and, in their representations of human actions, were, for the reasons above mentioned, colloquial and dramatic. Such are the poems of HOMER. The propensity, therefore, which early historians had to assume the dramatic form was, by the practice of their predecessors,

predecessors, both justified and enforced. Historians, from imitating conversation, came to imitate public speaking, and became oratorial. This change, however, was not merely an extension, so to say, of the preceding method. It was produced by other causes. The earliest ancient historians were natives, or recorded the deeds and revolutions, of independent republics. In these states, public speaking was very generally practised, and was often the cause of important events. The war between Athens and PHILIP, promoted by the oratorial powers of DEMOSTHENES; and the flight of CATILINE from Rome, occasioned by the eloquence of CICERO, are illustrious proofs. But not only did speeches, delivered in legislative or deliberative assemblies, in the senate or in the forum, produce important effects; other speeches, funeral orations and allocutions, were sometimes followed by very signal consequences. Ancient historians, therefore, were obliged to give us an account of such speeches; and, having before them the example of poets and very early historians, they adopted their method. They had also some other inducements. In the progress of improvement, the art of public speaking came to be highly cultivated. Rhetorical talents conferred great reputation, and the study of oratory became universal. It is not surprising, therefore, that historians should embrace such obvious opportunities as their subjects afforded them, of displaying their abilities in a species of composition so much esteemed. It has been remarked, that symptoms of this passion for oratory, so prevalent in Greece and Rome, may be discovered, even in some of their poets. Such was the origin, and such the different kinds of dramatic or rhetorical history.

II. It is obvious, that, so far as amusement is concerned, the method practised by LIVY, THUCYDIDES, and other ancient historians, has great advantages. It is a livelier method. It brings us, as it were, to the very scene of action. We are witnesses

nesses of the "very deed;" we are present in the senate, in the forum, or on the field of battle. Nor is this effect wonderful; for historians, by adopting the dramatic method, have an opportunity of diversifying their labours, not only with the ornaments, but with the impetuosity of rhetorical diction. Some of the speeches in LIVY are as animated and descriptive as the pleadings of CICERO. The advantages of the rhetorical form, in point of vivacity and amusement, are particularly manifest, when an historian, in relating an important event, has occasion to explain the state of parties, with the particular views and intentions of such leading men, especially in civil dissensions, as may have opposite interests. Such detail in modern history becomes often very tedious and unengaging, though it may have cost the writer much laborious research, and may be in itself important; yet the reader very frequently tires, and counts the pages. How much more interesting is it, when this information is conveyed to us indirectly, in an eloquent speech, and with all the graces of rhetorical expression! It was necessary for THUCYDIDES to inform his reader, that the state of Athens was accused by their neighbours of depredation, and to set before him the various interests, views or condition of those Grecian republics that entered early into the Peloponnesian war; and this he does in the most agreeable manner, in the speeches he attributes to ambassadors, or other persons in high office, among the Spartans, Corinthians, and Athenians. How distinctly, and with how much spirit does LIVY set before us the different rights, powers and pretensions of the patricians and plebeians at Rome, in the orations of APPIUS and CANULEIUS! Add to all this, that the dramatic method gives us an interesting display of character. Who is not more struck with the character of a Lacædemonian, in the following speech attributed to STHENE-LAIDAS*, than if it were described in a more direct, and even in a more circumstantial narrative! The Corinthian ambassadors at

* THUCYD. lib. I.

at Lacædemon had represented, that the prevailing power of Athens had rendered it necessary for the Spartans to interpose. The Athenian ambassadors, then present, reply to them in a long harangue: They wish to hinder the Lacædemonians from entering immediately into hostile measures; and take occasion to magnify and enumerate the mighty deeds of the Athenians, their power, and the services they had done to the Greeks. Thereupon STHENELEIDAS tells them, " I really do not understand the long harangue of the Athenians. They expatiate in their own praises; but say not a single word about the wrongs they have done to our allies, and to Peloponnesus. If they behaved well on a former occasion against the Medes, they behave ill at present, and deserve the severer correction, that, having known and practised what is right, they are now addicted to evil. But our conduct has, at all times, been uniform; and, if we act properly at present, we shall neither neglect the wrongs suffered by our friends, nor delay to assist them; for, in their sufferings, there is neither delay nor respite. Other states may have money, and ships, and horses; but we have good friends, whom we must not abandon to the Athenians. Nor is there any need for enquiries, or discussions in words; it is not by words alone that we and our friends are injured. Forthwith, and with all our might, we must give them aid. Nor let any one tell us, when we suffer injury, that we ought to reflect and deliberate. It is the business of those who meditate injury to reflect. Therefore, Lacædemonians, let us act consistently with the dignity of Sparta: Let us resolve on war; nor allow the Athenians to become too powerful, nor suffer our allies to be oppressed; but, confident in the favour of Heaven, let us take up arms against the guilty."

III. SINCE, therefore, the dramatic form has so many advantages; since it animates a narrative; gives an opportunity to
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the historian of borrowing assistance from the graces of eloquence ; imparts spirit to details, otherwise unengaging ; and gives an interesting display of character ; why should it be given up by the moderns ? Do they acknowledge themselves more destitute of fancy, sensibility, and powers of eloquent diction than SALLUST or TACITUS ? Other reasons have been assigned, and they deserve to be examined.

“ TRUTH,” it may be said, “ is the foundation of history. An historian must give a faithful account of facts, else he is no historian ; he is a novelist, a teller of tales, a romance-writer, and that of the worst kind ; for he would impose upon us as actual truth, what is even destitute of probability. Now, as it is not probable, that the speeches ascribed by ancient historians, to the great persons of whom they write, were ever delivered by them in the very form their historians have given them, they are guilty of deviation from truth and incur the censure we have expressed. Though CÆSAR and CATO might have delivered such orations as SALLUST has ascribed to them, it is not very likely that GAIUS and CORIOLANUS should have delivered the long speeches attributed to them by TACITUS and DIONYSIUS. The Romans and Caledonians, at the period when these men appeared, were illiterate and unimproved. The practice seems to have arisen among the loquacious Greeks, and to have been copied by the imitative Romans. It is, as was mentioned, a manifest violation of truth ; and if an historian, in any case whatsoever, appears regardless of veracity, how can we depend upon him on other occasions ? He impairs his own credit, and the whole of his evidence becomes suspected. Therefore, according to this view of the matter, the self-denial of modern historians does them great honour. Rather than trespass against the truth, and weaken the force of their evidence in matters so highly important, as the knowledge of past events, they deny themselves all the ornaments they might derive from the display of eloquence ;
and,

and, with a manly consciousness of the dignity conferred by their great office, they despise the praise of rhetorical ingenuity."

THIS argument seems very weighty. I shall, therefore, consider, in the *first* place, How far the dramatic form may be called a deviation from truth or probability; and, *2dly*, Supposing it to be so, whether the severity of the rule has not been relaxed in other particulars of higher moment, both by ancient and modern historians, but without destroying, or even weakening their credit.

1. How far, then, may the dramatic form be considered as a deviation from truth or probability? Were there no public speakers in Greece or in Rome? In the deliberations of Athenians and Romans, concerning affairs of the last importance, were there no public orators? Were there no funeral harangues? And were there no allocutions? Was it not customary for a commander, about to engage in battle, to assemble his army, and pronounce, in their hearing, such animated speeches as tended to rouse and preserve their spirit? Did not ambassadors pronounce elaborate orations? When the Ionians solicited assistance from the Greeks against the Persians, are we not told by HERODOTUS, that PITHERMUS, deputed for that purpose, arrayed himself in purple, and delivered an eloquent oration to the people of Lacedæmon? Ambassadors among the Romans were originally termed *pleaders**; they are so termed by VIRGIL, who never, so far as I know, deviates from the truth of nature in his delineation of manners. And ILIONEUS, who seems to have been the chief speaker among the Trojans, delivers himself with great eloquence both at Carthage and to King LATINUS. Or can we suppose, that those speeches, delivered so frequently, and on so many occasions, had not very

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powerful

* Tum fatus ANCHISA delectos ordine ab omni
Centum oratores augusta ad moenia regis.
Ire jubet,— *Æn.* vii. 150.

powerful effects in the great interests of republican states? These are facts which cannot be denied. If so, they ought certainly to be recorded. But are they to be recorded in the very general manner now mentioned? Is the historian to do no more than simply tell us, that certain persons, upon certain occasions, delivered speeches, on one side or other, in some momentous debate? A reader, entering with spirit into the narrative, would be desirous of knowing what arguments were employed; for if an effect, worthy of being transmitted to posterity, was produced by such speeches, the arguments they contained were, without doubt, its efficient cause. Therefore, if they are known, a faithful and intelligent writer will be very loath to suppress them, otherwise he becomes unfaithful. The historian, then, must give us an account of speakers, and of speeches, and of the arguments which they contain; but must he proceed no farther? The rigid severity of modern criticism, and the laudable love of truth, so peculiar to the moderns, pronounce an inviolable prohibition. He must not pretend to tell us, nor even to conjecture the method or arrangement observed by the speaker, and much less the words of the speech. It is, then, about the mere words of the speaker, or perhaps his method, that there is any dispute; and all the charge brought against ancient historians amounts to no more than that they alter the expression, and give the arguments of a speaker in the first person, rather than in the third. If they had done, as has been practised in some histories of England; if they had told us, that some peer or commoner had said *That* such and such were his views and conclusions, there would have been no transgression; and LIVY and THUCYDIDES are no otherwise blamed, than for exhibiting their speakers in the first person: Yet, surely, the faithful historian is a recorder of facts rather than of words. HERODOTUS, in one instance, has done the very thing which this criticism requires. He has given us the inelegant, though figurative language, spoken by some Persian ambassadors
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at the court of a Macedonian prince*; and has accordingly incurred the just, but reluctant blame of LONGINUS†. Or would you have a modern historian, in giving an account of the speeches in the House of Commons, give us the Irish of one, the broad Scotch of another, or vulgar English of a third? Or, in telling us the conversation of some foreign minister, ignorant of the English tongue, would you have him deliver it in the original German or Dutch? In such cases we make use of translation. Yet the idioms of modern European languages are so different from one another, that we shall find it, on many occasions, utterly impossible to give a literal translation of the very words. We must have recourse to circumlocution, and to such metaphorical expressions, as present very different images from those of the original. HELVETIUS has been charged, and I think not unjustly, with having offered to the public, as an original poem, a translation of the first scene of ELFRIDA‡; yet the difference between the two performances is much greater than that between presenting the views and arguments of a public speaker, as delivered by himself, or as related by an historian. Add to all this, that there can be no violation of veracity, when there is no intention of deceiving, much less when the reader is warned of his danger, and, in the very manner in which speeches are introduced, is guarded by the writer himself against imposition. TACITUS introduces the speech of GALGACUS with the words, “in hunc modum locutus fertur,” “is said to have harangued after the following manner;” and the speech of AGRICOLA with “ita differuit,” “thought proper thus to address them.” THUCYDIDES prefixes to a speech by the Corinthian ambassadors, “εἶπον τοιαυτά,” “they spoke such things;” and to that of STHENELAIDAS, “ἐλεξε τοῖς Λακεδαιμονίοις ὧδε,”

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* Lib. v. 18.

† De Sublim. sect. 3.

‡ MASON'S Memoirs of the life and writings of Mr GRAY, p. 296. edit. 4to.

“ he spoke to the Lacedæmonians in this manner.” SALLUST’S introduction to the speech of CÆSAR is of the same kind ; and the same observation may be illustrated in a variety of passages in LIVY. To what has been offered on this head, I shall add the following advice from LUCIAN, a writer of considerable judgment, and who treated fabulous history with very little indulgence. “ When it is necessary to make any one speak, you must take care to let him say nothing but what is suitable to the person, and to what he speaks about, and let every thing be clear and intelligible : Here, indeed, you may be permitted to play the orator, and shew the power of eloquence.”

UPON the whole, therefore, of this argument, I have little difficulty in concluding, that the charge of deviation from truth, in the dramatic form of historical composition, is ill-founded, or admits of great palliation.

2. BUT, supposing the case were otherwise, “ Has not the strict rule of veracity been relaxed in other particulars of higher moment, both by ancient and modern historians, without destroying or even weakening their credit ?” And, if so, why may not some indulgence be shewn to those writers who would enliven the detail of facts with the spirit of oratorical language ?

HISTORIANS, very frequently, not only record facts and events, but endeavour to trace and explain their causes. The causes, however, of great events often lie in the human mind ; in the passions and judgments of powerful men. It thus becomes necessary to investigate motives, detect inclinations, and explore the labyrinths of the human heart. How difficult a task ! How difficult, on many occasions, to discover the motives of our own conduct ! How difficult to ascertain the principles of action that instigate those persons with whom we are daily conversant ! How much more difficult to ascertain the motives of men who lived many centuries ago, and with whose private or peculiar habits

habits we are little acquainted ! Every investigation of this sort must be attended with uncertainty. Yet historians have, in this respect, been undaunted. They have proceeded boldly in unfolding the mazes of the human heart, in delineating characters, and in explaining great revolutions by the passions, desires, or interests of famous men. In some cases, motives are very obvious. When THUCYDIDES tells us, that the Lacedæmonians entered into the Peloponnesian war, not so much to protect the other Grecian states, as to hinder Athens from growing powerful, we assent very readily to his opinion. In like manner, when a modern historian, of uncommon elegance, informs us, in his history of America, that " PIZARRO, intoxicated with the success which had hitherto accompanied his arms, and elated with having again near a thousand men under his command, refused to listen to any terms* ;" we give easy credit to his account. At the same time, the only fact, of which we have sufficient evidence, is, that PIZARRO refused to listen to any terms. The motives alleged, though probable, are suggested by conjecture. The same observation is more fully illustrated in the following passage from MIDDLETON's life of CICERO, translated almost literally from DIO CASSIUS. " JULIUS CÆSAR also was a zealous promoter of this law †, " from a different motive than the love either of POMPEY or " of the republic. His design was, to recommend himself by " it to the people, whose favour, he foresaw, would be of more " use to him than the senate's, and to cast a fresh load of envy " on POMPEY, which, by some accident, might be improved afterwards to his hurt ; but his chief view was, to make the " precedent familiar, that whatever use POMPEY might make of " it, he himself might one day make a bad one." Had this historian been CÆSAR's father-confessor, he could not have been more intimately

* Dr ROBERTSON's Hist. of America, vol. ii. p. 255. edit. 4to.

† THE Manilian law.

intimately acquainted with his intentions and inclinations. Add to these illustrations, the various accounts given us by different historians, of the motives that influenced LUTHER in casting off his allegiance to the pope of Rome. By some, he is represented as being actuated solely by the love of truth, and, according to others, by resentment. In these, and a variety of other instances, we see historians of the highest reputation advancing their own opinions and conjectures, as matters of fact. This practice, indeed, is much more common, and more unrestrained among modern than among ancient writers, and is usually considered as a great improvement in historical composition. It is for this, more than for any thing else, that TACITUS is so much an object of adoration. Yet this practice, so very fashionable at present, often leads an historian into more flagrant violations of truth, and into bolder assumptions, than if he pretended to give us the language spoken by some famous speaker. The dramatic historian ascribes to his illustrious persons, probable words and phrases. The narrative historian, with intrepid boldness, ascribes to them probable motives, passions and inclinations. The first indulges conjecture in those things merely that are external, and that regard the form and manner. The second is indulgent to himself in those that are material and internal, and advances, as facts, his own guesses concerning the most delicate springs of action. Since, therefore, the strict rule of veracity is transgressed in this particular, with so much applause, why, in an instance of less importance, and when the transgression would be attended with advantages of another kind, may not criticism abate some of its rigour? Nay, in comparing what was formerly said with what has now been observed, the dramatic historian seems to have the higher title to this indulgence, that he seems, in truth, to be the more faithful writer of the two. The narrative historian gives you his facts and conjectures mingled together, and

and with equal authority ; so that it requires more patience and discernment than belong to a great many readers, to distinguish what ought to be received with immediate belief, from those things that depend for their evidence on the conjectural judgment of the narrator. Historians of another kind, (and this, in general, is the practice of XENOPHON and LIVY), give you their facts and their conjectures apart. Their facts constitute the narrative, and their views of characters and motives are thrown into those speeches, which, as we have seen, are not offered by the writers themselves as of equal authority with their relation of external events.

I HAVE thus endeavoured to point out the cause of the difference, stated at the beginning of this discourse, between the ancient and modern forms of historical composition, and have suggested some considerations by which the practice of antiquity may be justified. The same considerations do not extend to the history of modern European nations ; for the practice could not be supported by the same views of probability. In the revolutions of modern nations, public speaking has been of little importance. We have not now any funeral orations for political purposes ; other circumstances of military discipline have superseded the use of allocution ; our ambassadors have little occasion for rhetorical powers ; and we may add, that the deliberations of the British parliament are not much influenced by the oratory of even the most eloquent speakers. We may also observe, that the object of modern historians seems a good deal different from that of the ancient : They are become more philosophical ; they discover more accuracy in explaining causes, and more penetration in deducing effects. Oratory was the fashion in ancient times ; philosophy is the fashion at present. The ancient historian was often desirous of exciting sympathetic feelings, and of pleasing the fancy ; the modern historian is chiefly desirous of informing the understanding. Both methods
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are liable to perversion. The ancient historian was tempted to go too far in quest of rhetorical embellishment; the modern may be equally misled by the love of philosophical theory. Great would be the merit of that writer who could unite the elegant graces of the ancient historian, particularly of the colloquial kind, with the accurate research and comprehensive discernment of the modern.

VI. A GRAMMATICAL ESSAY on the NATURE, IMPORT,
and EFFECT of CERTAIN CONJUNCTIONS; particu-
larly the Greek ΔΕ. By JOHN HUNTER, M.A. F.R.S. EDIN.
and Professor of Humanity in the University of ST ANDREWS.

[Read by Mr DALZEL, Secretary, June 21. 1784.]

LEVIA quidem hæc, et parvi fortè, si per se spectentur, momenti. Sed ex elementis con-
stant, ex principiis oriuntur, omnia: Et ex judicii consuetudine in rebus minutis adhibitâ,
pendet sæpissimè etiam in maximis vera atque accurata Scientia.

SAM. CLARKE Præf. ad HOM. Iliad.

IT is a maxim in physics, that “ an effect ought not to be
“ ascribed to the joint operation of many causes, if fewer
“ are adequate to the production of it.” *Frustra fit per plura,
quod fieri potest per pauciora.* This maxim is no less just when
applied to language. It is equally unphilosophical in grammar
and in physics, to multiply without necessity the principles from
which the phænomena are to be explained.

IN the English, however, and in other languages, certain
words are classed by the grammarians as different parts of speech,
according to varieties observed in the application of them, even
when these varieties are merely *accidental*. Thus, in the sentence,
“ I came *after his departure*,” the word AFTER is classed with the
Prepositions; while, in this other, “ I came *after he departed*,” it is
classed with the *Conjunctions*. The word AFTER is, however, the
same in both sentences; its *meaning* is the same, and its *effect*
precisely the same. The only circumstance of discrimination
is, that, in the first example, it is prefixed to a noun substantive,

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—*his departure*; in the latter, it is prefixed to a nominative and a verb—*he departed*. But even the nominative and verb thus applied do not constitute a proposition; they do not contain an independent assertion; they express no more than a specifying circumstance annexed to the other proposition, “*I came*;” and, whenever they are rightly apprehended by the mind, they are stripped of their propositionary form, and stated *abstractly* under a new phrase—*his departure*. Thus considered, then, the two propositions are synonymous in every respect, excepting the *apparent* grammatical nature of the words—*his departure*, and—*he departed*; and even these are reduced to one grammatic form in the mind, whenever the import of the propositions is rightly apprehended.

FROM these observations it should seem that there is no sufficient reason for classing the word AFTER, in the one case, with the *Prepositions*, and, in the other, with the *Conjunctions*; since, by the seeming change of its regimen, no real change is made, either in its grammatical nature, or in its signification.

OF this unphilosophical method of arranging the same words in different classes, I shall mention *two* other instances, chiefly with a view to prepare the way for a conjecture which I am to offer with regard to the nature and import of one of the Greek particles; which instances will serve to illustrate and confirm that conjecture, and will, in their turn, be illustrated by it*.

I. THE English preposition TO is very variously applied. Being extremely *general* in its signification, it is consequently capable of various *special* applications. One of its special uses is to mark *addition* TO. Thus DENHAM,

“Wisdom he has, and, TO his wisdom †, courage;

“Temper TO that, and, unto all, success.”

In this example, every succeeding circumstance is, by the preposition

* In the progress of the essay, it will appear, that the reasoning proceeds upon an analogy much more strict and close than here it seems to do.

† ΠΡΟΣ τῆ σοφίας.

position *TO*, marked as an *addition to* the preceding. "Wisdom he has, and courage *additional to* his wisdom," &c. In this acceptance of the word *TO*, the object which it governs, or to which it marks something else as *added*, is frequently *not expressed*, or not formally stated along with the preposition. The reason is, that it readily occurs to the mind, being mentioned in the context immediately before. Thus DENHAM might, with equal propriety, have said,

"Wisdom he has, and courage too," &c.

This mode of expression would have been more concise and equally intelligible as the other, "Wisdom he has, and courage *TO his wisdom*," &c.

Not only is the object governed by *TO* omitted, when it is represented by a noun substantive in the context, but also when it is involved in a proposition. Thus Mr POPE,

—— "Let those eyes that view

"The daring crime, behold the vengeance too."

So "He made him prisoner, and killed him too." In the one example, the circumstance of *beholding the vengeance* is stated as an *addition to* the *viewing the crime*; and, in the other, the *killing him* is stated as an *addition to* the *making him a prisoner*. In both examples, the object governed by *TOO* is not formally stated; and, in both also, it is involved in a preceding proposition. It is the *amount* of that proposition taken *abstractly*, or as a *Noun substantive*.

ALTHOUGH all these uses of the word *TO* are really one and the same, differing in nothing but this, that the object governed by it is, in some of them, *expressed*, and, in others, *not expressed*; yet the grammarians have considered them as different, and have classed *TO*, in the one case, with the *Prepositions*, and, in the other, with the *Conjunctions*, or with the *Adverbs*. This circumstance, together perhaps with the accented pronunciation

of *TO*, when the object governed by it is not expressed, has given rise to a difference in its orthography, the writing it with two *O*s instead of one. And the two words have ultimately come to be universally considered as *different*, inasmuch that even the supposition of their being the *same* is not likely to be listened to without prejudice.

IN the parent Saxon language, however, both uses are comprised under one form, *to*; and, even in the English, as late as the reign of Queen ELIZABETH, they were both written with one *O*. This appears from the specimens prefixed to Dr JOHNSON'S Dictionary, as a history of our language previous to that period. Thus, Sir THOMAS MORE, speaking of fortune and one of her quondam favourites,

"She glydeth from hym, and her giftes *to*;

"And he her curseth, as other fooles do."

And to the accented pronunciation of *TO*, when its object is not expressed, that is, by no means, a sufficient reason, either for classing or for writing it differently, being a circumstance common to it with every preposition whatsoever. All of them, when their objects are expressed, may be accented or not accented, according to the meaning, or shade of meaning, intended to be conveyed. But, when their objects are not expressed, they are *commonly** accented: "*To stand by*," "*to come on*," "*to run in*," "*to rush out*," &c.

FROM these observations, it should seem, that the word *too*, though generally considered as different, and though ranked by grammarians in a different class of the parts of speech, is really the same with the preposition *to*, in its special meaning of *additional to*. This has been shown from the sameness of their *meaning* and *effect*, as well as of their *original orthography*, and
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* In fact they are *always* accented, though their accent may sometimes be obscured by an equal or superior accent given to an adjoining word, as, "He did not *walk in*, but *rushed in*."

the circumstances of *apparent* diversity have been accounted for. This, then, I think, may be fairly admitted as one instance wherein the various classing of the same word, founded on imperfect and partial views, tends to deceive, by leading us to suppose *grammatic* differences which are not real, and to consider *words* as different, when they are really the same.

II. I SHALL subjoin a similar example from the Latin language. The Latin preposition *AD*, like the English *TO*, is extremely *general*, and consequently capable of various *special* applications. One of these is to mark one object as *added to* another*. “*AD hoc*, promissa barba et capilli efferaverant speciem oris †.” “*Additional to this*, his long beard and hair had given a wildness to his aspect.”

BUT the object governed by *AD*, when used in this special meaning, is often not expressed, or not formally stated; and, in that case, like the English preposition *TO*, *AD* is classed with the *conjunctions*, and written differently, *AT*. Thus, as *ABS*, compounded with *que*, produces *ABSque*, so *AD* compounded with *que* produces *ATque*, *i. e.* *ADque*. “*BRUTUS ATque CÆSAR*,” “*BRUTUS and CÆSAR TOO* ;” “*BRUTUS, and CÆSAR additional to BRUTUS*.” “*CÆSAR DUMNORIGEM cepit, ATque interfecit*.” “*CÆSAR made DUMNORIX prisoner, and killed him TOO*.” In this example, the *killing* *DUMNORIX* is stated as *added to the making him a prisoner*. In these examples, it is evident, that *AT* marks one object as *added to* another, and differs from *AD*, when used in the same special meaning, in nothing but the *suppressing* of the object governed by it.

EVEN when *AT* appears by itself, and without *que* subjoined, it seems to be sometimes used in the same special meaning. Thus *TERENCE*,—“*PH. Fac, ita ut iussi, deducantur isti*.
“ *PA.*

* *Added to*—where *accumulation only*, or the increase of number or magnitude, is attended to.

† *LIVY*.

"PA. Faciam. PH. AT diligenter. PA. Fiet. PH. AT mature*." By the means of AT, the circumstances of *diligence* and *haste* are *superadded* to the action commanded. "PH. It is not enough that you do it, you must do it carefully too." "PA. Well; it shall be carefully done. PH. In good time too."

BUT further: *Another* of the *special* applications of the preposition AD, is to mark one object as *united* or *joined to*† another, and that, too, whatever be the nature of the objects, whether they be such as are *commonly* united, or such as appear *incongruous*, and whose union is contrary to expectation. Of the first kind is this example from LIVY: "AD imperium dictatoris, cuncta mota acies;" "*Joined to* the command of the dictator, the whole army was in motion"—i. e. "AT the command," &c. In this example, there is nothing incongruous in the objects united; their union is even considered as necessary, the *movement of the army* being joined to the *command of the dictator*, as an *effect* to its *cause*. Of the second kind is the following instance: "AD imperium dictatoris, discedere nolebant;" "AT the command of the dictator, they refused to depart." In this last example, the sentence is constructed in the same manner as in the other. Two events are represented as *conjoined*, a *refusal to depart* and the *command of the dictator*; and the same preposition AD is employed to mark their *union*. From our knowledge, however, of the power vested in the Roman dictator, we perceive, that these events are, in some measure, incongruous, and their union consequently unexpected. And this perception of incongruity in the objects united leads us to give to AD the force, not of TO simply, but of TO with emphasis, or EVEN TO. "Joined EVEN TO the command of the dictator, they refused to depart"—i. e. "EVEN AT the command," &c.

Now it is in this last manner, viz. to mark the unexpected union of incongruous objects, that AD, when the object which it governs

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* Eun. Act. ii. Sc. i.

† *Joined to*, in respect of time, as cause and effect, &c.

is not formally stated, *i. e.* *AT*, the *conjunction*, is most commonly applied, "Aulam tyranni frequentabat, *AT* patriam amabat;" literally, "He frequented the court of the tyrant; joined *EVEN* "to that, he loved his country." "He was a courtier and a "patriot too." By means of *AT*, the circumstance of *loving his country* is stated as *united* to the other, *viz. his frequenting the court of the tyrant*.—The character of a *patriot* is represented as *united* to that of a *courtier* in the same person.

CICERO, in his address to CÆSAR in behalf of MARCELLUS*, has the following sentence: "Nihil est opere aut manu factum, "quod aliquando non conficiat et consumat vetustas; *AT* vero hæc "tua justitia et lenitas animi florescet quotidie magis." Here first one truth is stated—"There is nothing made by the labour or "hand of man which length of time may not waste and destroy." Then, by means of *AT*, another circumstance is stated as *joined* *EVEN* TO this truth, *viz.* "That CÆSAR's justice and gentleness "of disposition shall flourish every day more and more." It is not *simply* asserted, that "CÆSAR's justice shall flourish," but that it shall flourish, *conjoined even* to the truth of the other position—"That every work of the hand must perish"—a position which we conceive to be almost incompatible with it. Instead of *AT* *vero*, CICERO might have used *AT* *tamen*. "Every work "must perish, *yet* *JOINED* *EVEN* TO THAT, your justice shall "flourish." The former circumstance shall not prevent the truth of the latter. In these, and in all similar examples, the two objects or events, however incongruous they may *seem* to be, are actually *united*; and of their union, *AT* appears to be the symbol †.

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* Cap. 4.

† THE frequent application of *AT*, to mark the union of incongruous objects, first gave rise to the habit of annexing an emphatic meaning to it; and, when once this habit was formed, the word necessarily raised an expectation of something incongruous to follow. And hence it has come at last to be mistaken for a *symbol* of incongruity or opposition.

It would be difficult to collect examples of *all* the various applications of the word *AT*, that may be met with in the Latin authors. In those, however, that most frequently occur,

THE word *AT* is indeed called an *adversative*, and is commonly imagined to mark, not the *union*, but the *opposition* of objects. But,

I. THE authority of *QUINCTILIAN* is explicit in favour of our hypothesis. In treating of the Latin orthography, he has the following observation: "*Illa quoque servata est a multis differentia, ut AD, quum esset præpositio, D literam; quum autem*

occur, it is evidently expressive, not of *opposition*, but of *union*. When there is no incongruity in the objects united, and consequently nothing unexpected in their union, the effect of it will be perceived by rendering it *TO* simply; and, when the objects united appear incongruous, by rendering it *TO* with emphasis, or *EVEN TO*.

I. *To simply*—as in the form of surrender recorded by *LIVY*, [*Lib. i. cap. 38.*] "*Deditisne vos populumque Collatinum in meam populi Romani ditionem? Deditis. AT ego recipio;*" "*Joined TO that, I receive them.*" *ET* might have been used in this instance. In imprecations, and the like, it represents the amount of the prayer, as *joined to* an action *mentioned, perceived, dreaded, &c.* 1. *To an action mentioned*; as in *TERENCE*; "*CH. Factum est hoc, DAVE? DA. Factum. CH. Hem! quid ais, Scelus? AT tibi dii dignum factis exitium dunt!*" 2. *To an action perceived*; as in *VIRGIL*, when *PRIAM*, upon seeing his son killed by *PYRRHUS*, exclaims:

"*AT tibi pro scelere, exclamat, pro talibus ausis,*
 "*Di, si qua est cælo pietas, quæ talia curet,*
 "*Perfolvant grates dignas, et præmia reddant*
 "*Digna,—qui nati coram me cernere letum*
 "*Fecisti, et patrios foedasti funere vultus.*" [*Æn. ii. 535.*]

II. *EVEN TO*—as in *TERENCE*; "*Si ego digna hac contumeliâ sum maximè, AT tu indignus qui faceres tamen;*" "*Joined EVEN TO that, it was unworthy of you to do it.*" So when *CHREMES*, after he has heard many circumstances tending to prove that *PAMPHILA* is his daughter, says, "*AT mihi unus scrupulus etiam restat.*" "*Joined EVEN TO [what I have heard] there still remains one difficulty.*" *i. e.* "*All I have heard is not sufficient to remove it.*" It is used precisely in this manner, when it introduces an *objection*, or the *answer* to an *objection*. 1. *An objection*; as in *CICERO* pro *MILONE*; "*AT valuit odium, fecit iratus, &c.*" "*Joined EVEN TO [what you have said] his hatred got the better of him, he acted from passion:*" *i. e.* "*For all that you have said,*" &c. "*All that you have said does not hinder the deed to have proceeded from hatred or passion.*" 2. *The answer to an objection*; as, "*Domus tibi deerat? AT habebas. Pecunia superabat? AT egebas.*" "*You will say you wanted a house; joined EVEN TO that, you had one,*" &c. It is used in this manner too, when it introduces the *circumstances* of an action which tend to heighten our surprise. "*Vidit CLODIUS necesse esse MILONI proficisci Lanuvium illo ipso, quo profectus est, die; itaque antevertit. AT quo*

" *autem conjunctio*, τ acciperet *." From this passage, it is evident, that the conjunction *AT* was originally written *AD*: That the difference in their orthography, though observed by *many*, was not, at that time, *universally* observed; and that this difference was introduced to distinguish the conjunction from the preposition. The fortune of the Latin *AD* appears, therefore, to have been similar to that of the English *TO*. Both of them are *prepositions*, and of the *same* signification. Both of them, when the object which they govern is not formally stated, have been reckoned *conjunctions*; and, in both, a difference of *orthography* has at last obtained to distinguish the *conjunction* from the *preposition*.

2. THE propositions, whereof *AT* is said to mark the opposition, are both of them *true*, and they express truths which are *co-existent*. They cannot, therefore, be *opposite* in one of the acceptations of that term. They may be *apparently* incompatible, but they are not *really* so. Thus, in the example formerly mentioned, "Aulam tyranni frequentabat; *AT* patriam amabat,"—the two characters of *courtier* and *patriot*, however incongruous they may *seem* to be, are represented as *united* in the same person. Considering the matter *a priori*, then, it seems reasonable to imagine, that, on such occasions, a term would be employed to mark the *union*, which is *uncommon* and *unexpected*, rather than the *opposition* or *incongruity*, which is *apparent*. Accordingly, we find, in fact, that those of the conjunctions called

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"quo die? Quo, ut ante dixi, infanissima concio ab ipsius mercenario tribuno plebis est concitata: Quem diem ille, quam concionem, quos clamores, nisi ad cogitatum facinus approperaret, nunquam reliquisset;"—"On what day, too?" &c. This is an instance extremely fortunate for our purpose; because, although the *action* of *CLODIUS* and the *time* which he chose for it appear incongruous, yet the practice of the English language admits of our rendering *AT* literally; "CLODIUS was beforehand with him, on a day too when his presence was necessary at Rome."

In the foregoing examples, which comprehend all the common applications of *AT*, it seems to mark the *union*, [*expected* or *not expected*], not the *opposition*, of the objects connected by it.

* Lib. i. cap. 7.

ed *adversative*, whose signification can be ascertained, are significant, not of *opposition*, but of *union*, or something that is equivalent. Of this kind are the Greek, ὅμως, accented on the penult, and αἰ; the Latin, *etsi*, *verum*, *vero*, *tamen*, *verum tamen*; the French, *cependant*, and perhaps *encore*; the English, *yet*, *nevertheless*, *notwithstanding*, &c. It might, however, be reckoned tedious, were I to attempt to state the precise import of each of these, and to show, that their effect, in a sentence, is consonant to their signification, and arises out of it.

3. THE *adversative appearance* of AT seems to have arisen from the circumstance of its raising an *expectation*, that something seemingly opposite, or incongruous, is to follow. Thus, when it is said, "CÆSAR fuit vir fortis, prudens, clemens; " AT ———," the word AT is no sooner heard, than an expectation is raised, that something opposite to the qualities previously mentioned—something disadvantageous to the character of CÆSAR, is to follow. And hence, from its raising this expectation, it has been concluded, that AT itself is significant of opposition: But that this conclusion is by no means *necessary*, will appear from the following observations.

WHEN objects or qualities, considered as in their own nature opposite or incongruous, are observed to co-exist, it seems more necessary to *intimate their co-existence*, than if no such opposition were felt. The perception of their *natural* incongruity leads to the giving a *marked* intimation of their *union*, when they happen to be united. "CÆSAR fuit vir fortis, prudens, clemens; AT ambitiosus, patriæ proditor," &c. It might have been imagined, that such opposite qualities could not unite in the same person; and, therefore, it appeared necessary, that pointed intimation should be given of their union; and, for that purpose, the word AT is employed. The same circumstance, *viz.* the perception of the incongruity, also leads the hearer to *interpret* the symbol of union in the same *emphatic* manner; that is, to give to AT the force, not of TO simply, but

but of *TO* with emphasis, or *EVEN TO*. "CÆSAR possessed fortitude, prudence, clemency; joined *EVEN TO* that, he was ambitious, and a traitor to his country."

Now, this emphatic meaning, which men were *accustomed* to annex to *AT*, in consequence of its being so very frequently employed to mark the union of incongruous objects, will sufficiently account for its raising an expectation that something apparently opposite, or incongruous, is to follow: For, no sooner is this emphatic meaning given to it, than such an expectation is raised,—and *must* be raised, because an emphatic intimation of union *supposes* an incongruity in the objects united, and is given in consequence of a perception of that incongruity. Thus, "CÆSAR possessed fortitude, prudence, clemency; joined *EVEN TO* that ———." When these last words are heard, we immediately expect that something is to follow, apparently opposite to what is contained in the first member of the sentence. We are prepared for such attributes as—*ambitious* and a *traitor* to his country. Thus, then, from the emphatic meaning given to *AT*, an expectation was raised that something incongruous was to follow; and, from its raising this expectation, the word has preposterously been imagined to *express* that incongruity or opposition, which it only *presupposes*.

ANY emphatic intimation of union, thrown into a sentence, will raise an expectation that something incongruous is to be subjoined; and the reason is the same in them all, namely, that every such intimation is given on the supposition, that the objects are perceived to be naturally incongruous. "CÆSAR was brave, prudent, merciful; *at the same time*, he was ———." Or, "CÆSAR was brave, prudent, merciful; *notwithstanding that*, he was ———." In these, as well as in the Latin example, we are led to expect that some circumstance in the character of CÆSAR is to follow, which we should not have expected to be united with the qualities, bravery, prudence, and clemency. Yet the words, *at the same time*, do not express *opposition*, and not-

withstanding expresses almost the *contrary*. I appeal, then, to the judgment of every candid man, whether the circumstance of *AT* raising an expectation of something opposite to follow, ought to be considered as sufficient to found the conclusion, that *AT* itself denotes opposition; and, if it is not, I know no other ground on which such a conclusion is founded.

WHAT, then, are the *views*, or considerations, upon which the words, *at the same time*, and *notwithstanding*, are used in the preceding examples? When, in contemplating the various qualities which constitute the character of CÆSAR, we observe them to be such as, from their nature, are generally conceived *not to co-exist*,—*this view* of them leads us to obviate the general prejudice, by intimating that (in this particular instance) they existed *at the same time*. When, again, we consider them as naturally *opposite*, or conceive, that the one class of them has a *natural* tendency to *oppose* or prevent the existence of the other, *this view* of them leads us to intimate, that (in this instance) it did *not oppose* it; and it is for that purpose that we employ the word *notwithstanding*. In the same manner precisely, when a Roman viewed these qualities as naturally *incongruous*, he was thereby led to give notice that (in this particular instance) they were *united*; and, for this purpose, the word *AT*, *i. e.* *AD*, is employed.

It should seem, then, that the conjunction *AT* is an intimation, not of *opposition*, as is generally supposed, but of *union*; and that the habit of annexing an emphatic meaning to it, is sufficient to account for its raising an expectation, that something apparently opposite or incongruous is to be subjoined.

ACCORDINGLY, if, in any instance, we give to *AD*, even in its *undisguised* form, the emphatic sense of *even to*, a similar expectation will be raised. “*AD imperium dictatoris —.*” “*EVEN AT the command of the dictator —.*” When these words are heard, we instantly expect something to be added, which but ill accords with our notions of a dictator’s authority, whether

whether it be a refusal to depart, or any thing else of a like nature. "AD imperium dictatoris discedere nolebant." "EVEN AT the command of the dictator, they refused to depart."

Now, in this last example, and in every other of the same kind, by varying the structure of the sentence, AT may be introduced instead of AD, without even the slightest variation in the meaning. "Dictator imperabat; AT discedere nolebant." Wherein, then, does this last mode of expressing the idea differ from the former? In the former, the dictator's giving the command is *not asserted*; it is presupposed, and appears only in the *abstract* form of *imperium dictatoris*, governed by AD; whereas, in the latter, it is formally *asserted*; "Dictator imperabat;" but the *abstract amount* of the assertion, viz. "*imperium dictatoris*," is not repeated as the object governed by AT. In the one, the *formal assertion* is omitted, and the *abstract amount* of the assertion is expressed; in the other, the *abstract amount* is omitted, and the *formal assertion* is expressed. In these circumstances, and in these only, the two modes of expression seem to differ.

FROM the preceding observations and examples, it appears, that AT is nothing else but the preposition AD, taken in the special meanings—*added to*—*joined to*, and not having the object which it governs formally expressed; and that however opposite the objects may appear to be which it unites, yet it does not *express* their opposition.

THE word AT, as it denotes addition, might, indeed, be considered as implying *difference*; for if an object is stated as additional to another, it must be at least *numerically* different from that other. And, indeed, AT agrees with the Greek αλλα, the Latin *cæterum*, and the French *mais*, in this respect, that all of them imply *difference*, but none of them *opposition*. The last of them particularly, *mais*, (*magis*), like the Latin AT, implies *difference*, only because it denotes *addition*.

WE have now seen, that the English TOO and the Latin AT, are really the same with TO and AD; that they are, in truth,
nothing

nothing more than special applications of these; and we have shown on what these specialities depend, and that their effect in a sentence is actually such as, by their original signification, they may be supposed to produce; or, what amounts to the same thing, that the effect of them may be satisfactorily explained, by resorting to their proper and primitive signification.

III. LET us next enquire, whether the preceding observations can throw any light on the nature and import of the Greek particle ΔΕ, for the sake of which, chiefly, they have been premised.

1. THIS particle is, not uncommonly, found after the accusative case of *proper* names of places, when motion to these places is expressed. “ΙλιονΔΕ,”—“To Troy,” &c.

2. NOT only is it thus affixed to proper names, but also to *common*, or appellative, nouns, and in the same sense; “οικονΔΕ,”—“To a house.” “αγορηνΔΕ,”—“To the forum.” “αλαΔΕ,”—“To the sea,” &c.

3. IT is not affixed to the accusative singular only, but frequently also to the accusative plural, “οικαΔΕ.” When, however, the accusative plural ends in *ς*, it is often disguised by a transposition, the letters *δ* and *σ* being transposed for the sake of the sound. Thus, “ΑθηναςΔΕ,”—“To Athens,” is commonly written “ΑθναZE.” So “χαμαZE,”—“To the ground;” “ΘηβαZE,”—“To Thebes,” &c.

4. IT is not only applied, in this manner, to the place to which *real* motion tends, and at which it is conceived to terminate, but also to that object, whatever it be, to which any action is directed as a *final cause*. Thus HOMER*, “Μη αγορευε φοβον-ΔΕ”—literally, “Do not speak to flight.” Let not your speech tend to flight; let not flight be the *object*, or *final cause*, to which it is directed. The Latins use *ad*, and the English *to*, in the same manner. “Hoc fecit *ad* honorem meum,”—“He did this to my honour;” where his *doing this* is, in like manner, considered as *tending to* my honour.

THE

* Iliad. ε. 252.

THE word *ΔΕ* was, indeed, but seldom joined with an accusative case by the *Attic* writers, and only in some expressions which the grammarians consider as *adverbial*. May we not, however, conclude from the facts just now stated, that, with the more early Greeks, and even with HOMER, it was considered as a *preposition* governing the accusative, and equivalent to the Latin *AD*, or the English *TO*? It is, indeed, always put *after* the noun which it governs; but that makes no difference as to its *real* grammatical nature: For though a *pre-position* put *after*, is, in truth, a contradiction, yet it is no uncommon occurrence in most languages. The Latins use *nobis-cum*, *tantis-per*, &c. and we there-*to*, where-*to*, and others similar. These last also our grammarians consider as *adverbs*; but they are compound words, in which the preposition *TO* is palpably one of the component parts. And the facts before stated render it, in some degree, probable, that the Greek *ΔΕ* is sometimes, in like manner, a preposition put after the word which it governs, and equivalent to *TO*.

ON this hypothesis, then, that *ΔΕ* is a preposition signifying *TO*, it is reasonable to imagine—1. That, though it is, in itself, extremely *general*, yet, like the corresponding word in other languages, it may be used in the *special* meanings of—*added to*—*joined to*, &c. And—2. That the object, governed by it, may be not formally stated, but left to be collected from a preceding *noun* or *preposition*. In short, that it should follow the same analogy of application as the Latin *AD* and the English *TO*, when they are called *conjunctions*. Accordingly we find, that it does so in fact. When ULYSSES, in the 9th book of the *Iliad*, enumerates to ACHILLES the presents intended for him by AGAMEMNON, he does it in this manner:

————— “ ἐγὼ τοι καταλέξω
 “ Ὅσσα τοι ἐν κλισίῃσι ὑπέσχετο δῶρ’ Ἀγαμέμνων·
 “ ἑπτ’ ἀπύρες τρίποδες, δέκα ΔΕ χρυσοῖο τάλαντα,
 “ Αἰθωνὰς ΔΕ λεβητάς εἰκοσι, δώδεκα Δ’ ἵππους *.”

In

* V. 265.

In this example, by means of *δε*, each succeeding article is represented as *TO*, *i. e.* *additional to* the preceding article. “Seven tripods—ten talents of gold *TOO*”—*i. e.* “Ten talents of gold *additional to* the seven tripods.” This instance is precisely similar to that formerly quoted from DENHAM, except that the object governed by *δε*, and to which the succeeding article is added, is not repeated along with *δε*. In DENHAM it is,

“Wisdom he has, and, *TO his wisdom*, courage”—

which, if expressed according to the Greek idiom, in the example quoted from HOMER, would be,

“Wisdom he has, and courage *TOO*.”

In the above example, then, the word *δε* is used in the special meaning of *additional to*, and the object which it governs is *not formally stated*, but is collected from a preceding *noun*.

Again, XENOPHON, describing the Persian polity, says,—
 “Διδασκεσι τας παιδας σωφροσυνην· διδασκεσι ΔΕ πειθεσθαι τοις αρχεσι.”—
 “They teach the children temperance; they teach them, *TOO*, obedience to the magistrates.” In this example, by means of *δε*, their *teaching the children obedience to the magistrates*—is represented as *additional to* their *teaching them temperance*. Here also the object governed by *δε* is not expressed; it is collected from the preceding *proposition*—*διδασκεσι τας παιδας σωφροσυνην*. It is the *amount* of that proposition, taken as a *substantive*. So HOMER, in the beginning of the Iliad, says, that the anger of ACHILLES—

————— “μυρι’ Ἀχαιοῖς ἀλγέ’ ἔθηκε,
 “Πολλὰς Δ’ ἰφθίμης ψυχὰς αἰδὶ προΐαψεν
 “Ἡρώων.”—————

In this passage, first one event is stated, “*The anger of ACHILLES brought numberless woes upon the Greeks* ;”—then another,
 “*It*

"It sent many brave souls to PLUTO before their time;" and, by the means of δε, the last event is represented as *additional* to the former. "It sent, TOO, to PLUTO many brave souls of heroes." In this example, also, the object governed by δε is not expressed. It is, however, obviously suggested by the context; being the amount of the preceding proposition taken *abstractly*, or as a noun *substantive*. It is unnecessary to multiply examples. Every page of every Greek author abounds with them; for of this kind are all those in which the sense leads us to render δε—*and*.

BUT δε is often said to denote *opposition*. In truth it *never* does. In this respect it agrees exactly with the Latin AT. The events which it unites may appear opposite; but δε does not intimate their being so: It only marks the one as *added*, or *united*, to the other. This I am warranted in affirming, by the authority of the learned, ingenious, and most laborious HOOGEVEEN, an authority that will not be questioned, at least as to the *facts* of the Greek language. His words are:—"Δε ponitur et pro
" ἅλλα διαφορικῶς καὶ ἐναντιωματικῶς, five MEN præcedit, five non. vel
" *potius* dicam sententiæ diversæ aut adversanti additur, ita ut
" vicem τὴ ἅλλα explere videatur; non enim ipsi particulæ δε ea
" potestas attribuenda est, sed *sententiæ* cui apponitur *."

FURTHER,—That the same word should be employed to denote sometimes the *union*, and sometimes the *opposition* of objects, is a supposition, in itself, extremely improbable; because, in that case, the nature of the objects themselves could alone determine which of these significations we ought, in any particular instance, to affix to it; and, if so, their opposition might be discovered without the help of this ambiguous symbol of it. Δε, indeed, like the Latin AT, is often employed to mark the union of incongruous objects; and, like AT too, it has then been imagined to express that opposition which it only presupposes.

* Doctr. Particul. L. Gr. p. 245.

poses. Thus, when ORESTES, in EURIPIDES, makes the following observation—

“ Ονομα γαρ, εργον ΔΕ ουκ εχουσιν οι φιλοι,

“ ‘Οι μη επι ταισι συμφοραις οντες φιλοι *,”—

it is said, that δὲ states an opposition between the *name* and the *reality* of friendship: But, when the observations formerly made on ΑΤ, and the signification of δὲ, *ascertained* by the preceding examples, are taken into consideration, it seems much more reasonable to suppose, that, even here, it retains its proper signification of *union*. Literally thus—“ For the friends that are “ not friends in adversity have the *name* of friends, not the *reality* “ ΤΟΟ.” “ *Nomen, ΑΤ non rem habent.*” Two propositions in fact are stated, *viz.* “ That the friends that are not such in “ adversity have the name of friends;” and secondly, “ That “ they have not the reality:” And, by the means of δὲ, intimation is given, that—(whatever *might* have been expected) the latter is *united* to the former. This seems to be the precise meaning of the passage; and it is elicited without departing from the *known* signification of δὲ. Let us take an example still more striking. Suppose that it is said of a person— “ εστι μιν νεος, εστι ΔΕ σοφος ”—“ He is young, but he is wise.” The same person is represented as possessing *at once* the two seemingly incongruous qualities of *youth* and *wisdom*. Can any person allege, that, in this example, it is reasonable to depart from the *known* signification of δὲ, and to consider it as denoting *opposition*? The opposition between *youth* and *wisdom* is sufficiently apparent, without any expressed symbol of it. Is it not more reasonable to suppose δὲ to give notice, that—(whatever might have been expected—however opposite or *incongruous* these qualities may *seem* to be) they are (in this particular instance) *united*: That *his being wise* is represented as joined *EVEN TO* his *being young*? This, at least, is the intimation that every person *feels*

* Orest. 455.

feels himself prompted to give, when he observes the union of such incongruous qualities.

It should seem, then, that the conjunction $\delta\epsilon$, even when it is said to mark opposition, and translated *but*, still retains its genuine signification of *union*,—with this variation, however, that from the perceived incongruity of the objects, and the unexpectedness of their union, we ought to give it, in such instances, the force, not of *TO* simply, but of *TO* with emphasis, or—
EVEN *TO*.

BUT $\delta\epsilon$, when it appears in the form of a *preposition* governing the accusative, is not accented,— $\epsilon\lambda\upsilon\mu\pi\omicron\nu\Delta E$ — $\kappa\lambda\iota\sigma\iota\eta\nu\Delta E$, &c. ; whereas $\delta\epsilon$ the *conjunction* is always accented. If they are one and the same, whence arises this difference? This circumstance, among others, has led the very learned and ingenious author quoted above, to imagine them to be altogether different, and of different origin. His words are :—“ Cæterum quoties ΔE $\epsilon\gamma\kappa\lambda\iota\nu\epsilon\iota\alpha\iota$, “ non conjunctio est, sed syllabica adjectio, nec *quicquam* cum “ particula $\delta\epsilon$ *commune* habet *. But, notwithstanding this seeming difference between them, and notwithstanding the great authority now quoted, we cannot hesitate to regard them still as the *same* word. For, if rightly considered, this difference as to accent, in the pronunciation at least †, instead of being an objection, is really a confirmation of our hypothesis ‡. We have seen already, that the prepositions, when the object which they govern is expressed, are commonly *not* accented,—“ He came *to* “ Rome.” In like manner $\delta\epsilon$, when its accusative is expressed, ought, upon this analogy, *not* to be accented,—“ $\epsilon\lambda\upsilon\mu\pi\omicron\nu\Delta E$:” That, on the other hand, when the object governed by them is not expressed, or not formally stated, the prepositions are then *accented*, “ Wisdom he has, and courage *too*.” $\Delta\epsilon$, therefore, when
r 2 the

* Doctr. Particul. L. Gr. p. 262.

† With regard to the accentual *marks*, they seem to have owed their origin to an unsuccessful attempt to perpetuate a particular *mode* of pronunciation.

‡ As far at least as a thing so little known as the nature of Greek accent can be allowed to have weight in the present case.

the object which it governs, or to which it marks something as *united* or *added*, is not expressed,—that is, Δ the conjunction—ought, upon the same analogy, to be then accented. Were this a proper occasion for such a discussion, it might even be shown, that this analogy, in giving and with-holding the accent, is not arbitrary, but founded on principle.

MAY we not then conclude, with some degree of probability, that Δ the *conjunction* is not a different word from Δ the *preposition*, or *post-fix*, but only a special application of it? If this conclusion be admitted, it appears, that the conjunctive use of the Latin *Ad* and the English *To* illustrates the nature and use of the Greek conjunction Δ ; and that *it*, in its turn, serves to illustrate and confirm the account that was given of *them*. All of them represent the *same idea*; and, in the three taken together, there appears a beautiful gradation in the application of it. The English *Too* being applied as a *simple* intimation of union, is accounted an *additive* only; the Latin *At*, giving commonly an *emphatic* notice of *unexpected* union, is considered as an *adversative*; and the Greek Δ , being applied in *either* way indifferently, will appear *additive* or *adversative*, according to the *degree of emphasis* given to it, that is, according to the *nature of the objects* which it unites.

BUT what real knowledge have we gained in the progress of this long enquiry? The answer is,—That the *classing disparate phenomena*, and referring them to one common principle, is held to be *science* in *Physics*,—and why should it not also be accounted *science* in *Grammar**? But, not to give an answer which may seem captious, we have seen——

I. THAT

* THE observation in the text, although extremely common, appears to mistake the *half of science* for the *whole*. It is undoubtedly the part of science to investigate what, in dissimilar objects, is *generic*, or common to the whole: But to discern and to mark what is *specific*, or peculiar to each, is no less the business of science; and, as it is commonly of greater difficulty, so it is at least of equal importance. The author, therefore, has attempted, whether successfully or not, to ascertain what is peculiar with regard either to *grammatical nature*, or to *signification*, in the various applications of the words he has discussed.

1. THAT *Prepositions*, in various languages, govern not only nouns substantive, but also clauses of sentences bearing the form of propositions; but that such clauses are then equal to nouns in their *effect*, the *abstract amount* of them only being regarded: And, consequently, that, by this *seeming* change of their regimen, no *real* change is made, either in the grammatical nature, or in the signification of the prepositions themselves.
 2. THAT, whether the object governed be a noun substantive, or the amount of a proposition taken as a noun substantive, that object is often not formally stated, being obvious from the context; but that neither does the *formal statement*, or the *omission* of the governed object, make any change, either in the grammatical nature, or in the signification of the prepositions.
 3. THAT the specialities attending these *prepositions*, when they are called *conjunctions*, depend, in as far as the *expression* is concerned, on one or other, or both of the following circumstances, *viz.* the governed objects *being involved in a proposition*, or its *not being formally stated*.
 4. THAT the adverbative *appearance* of some of the conjunctions called *adverbative*, arises solely from the *emphatic* meaning given to them, when employed to mark the union of objects *seemingly* opposite or incongruous; but that, though they may *presuppose*, they do not *express* such incongruity or apparent opposition.
 5. BY having shown that the conjunctions *Too*, *At*, and Δi , are the same with the prepositions *To*, *Ad*, and Δe , we have discovered their strict and proper signification, and are thereby enabled to annex to each of them a *precise idea*, instead of having a vague and confused *feeling* of their *effect*.
- Lastly*, BY having ascertained the grammatical nature of *certain* conjunctions, we have advanced *one* step towards the development of the nature of the *Conjunction* itself,—I mean the
- part*

part of speech so called,—which is still a *Desideratum* in grammar, the nature of it being, perhaps, less understood than that of any other of the parts of speech *.

* THE author is fully sensible that, in several places of this essay, he has used expressions which, to an English reader, must appear extremely uncouth. Convinced as he is, that the word AD or AT, and ΔΕ, however variously applied, are always representative of the *same idea*, he has attempted to *hold that circumstance up to view*, by using always the same English word, *to*, in translating them. Now, in this attempt, such uncouthness was unavoidable; for it happens that the Greek, Latin and English languages have not followed always the same range in the *application* of these words, although they are in *themselves* strictly synonymous. And whenever the usage of our language does not correspond with that of the Greek or Latin, a literal translation cannot be attempted, without a manifest violation of the propriety of the English idiom:—In truth, it frequently happens that words of the *same generic meaning* are found in *very different special applications*, in different languages. For example, the Greek preposition ANTI, and the Latin ANTE, not only represent the *same idea*, viz. priority, but they are really the *same word*; and yet the special applications of them are by no means correspondent with each other, ANTE, in Latin, never marking opposition, nor ANTI, in Greek, priority in respect of time.—On the other hand, words that are very different in their original import, frequently produce the same ultimate effect. Thus the words AD and EX are not only of different, but nearly of opposite meaning; and yet, of the two expressions, “AD suam naturam fingere cæteros,” and “EX sua natura fingere cæteros,” the effect is ultimately the same.

VII. ESSAY *on the* ORIGIN *and* STRUCTURE *of the* EUROPEAN LEGISLATURES. *By* ALLAN MACONCHIE, Esq; Advocate, F. R. S. EDIN. *and* Professor of Public Law in the University of EDINBURGH.

P A R T II.

SECTION I. *Of the Legislature of the German Nations during the first Ages after their Establishment in the Roman Provinces* *.

[Read by the Author, July 19. 1784.]

IT is reasonable to suppose, that the founders of the European states would, at least for some time after their conquests, retain much of their former political arrangements. The idea, therefore, which I have formed of their legislatures in their new situation may, in a great measure, be anticipated from the observations contained in the preceding part of this paper. At the same time, the change from the wilds of Germany to the cultivated provinces of the empire was very great: And it is necessary to survey, in general, the aspect which, on this event, the German governments might be expected to exhibit, in order, either to form an accurate conception of the general hypothesis I have adopted, or to perceive the propriety and application of those discussions which are intended for its support.

AT the close of an expedition of a German confederacy which had been crowned with conquest, I apprehend that their general, or common leader, would not lay down his authority as in ordinary cases, where victory, rather than new settlements, formed

* See PART I. at the beginning of PAPERS OF THE LITERARY CLASS in this VOLUME.

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AT the close of an expedition of a German confederacy which had been crowned with conquest, I apprehend that their general, or common leader, would not lay down his authority as in ordinary cases, where victory, rather than new settlements, formed

* See PART I. at the beginning of PAPERS OF THE LITERARY CLASS in this VOLUME.

formed the object of the war. The influence he must have acquired in the course of the conquest, and a general sense that the security of the new acquisitions depended on preserving the union which had gained them, would necessarily perpetuate his office, and render it regal. The confederated tribes, again, in accommodating themselves to their new situation, would adhere as much as possible to their ancient habits. The conquered country would like their old domains be parcelled out, *gentibus cognationibusque hominum*; and these tribes would, of course, give their names to their new settlements, and would arrange themselves into those divisions and subdivisions, *pagi* or *shires*, hundreds and tithings, by means of which alone their civil, political, and military affairs had formerly been transacted. The old assemblies would still be celebrated, the old military parade exhibited, and the old religious rites solemnized.

As the conquerors were generally much inferior in numbers to those they had subdued, and as their habits of independence, and their contempt for the mercenary troops which they had been accustomed to vanquish, must have rendered it impracticable to keep on foot a standing army, the importance of preserving military subordination and arrangement among themselves was, without doubt, universally perceived, and the measures that appeared essential for this purpose must, therefore, have been adopted, whatever might be the inconveniences with which they were attended. On this account, not only the military exercises and evolutions, formerly practised at the assemblies of each *pagus* and its subdivisions must have been continued, but it would be universally found necessary to have once a-year at least a general muster of the whole confederacy, and to attribute to their general or king the right of calling forth the nation in arms when he saw cause, and of enforcing the observance every where of those regulations which had been made at their general meetings, by common consent.

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At such general musters, the king would hold a council, with the chiefs of the different tribes, about such affairs as could not be transacted without the national concurrence; and what they resolved on would, when proposed to the multitude, be in general approved of: But, on some singular occasions, the people might entertain different sentiments from their chiefs; and instances, therefore, may have occurred, not only of such proposals being rejected, but of opposite resolutions being embraced.

THE power by which the king exercised his new authority would naturally be founded in the influence of his old retainers, and in the habits of the vanquished natives, which must have universally disposed them to attribute to him the prerogatives of the imperial crown. From this last source, the forms of official business, which, as far as preserved, were necessarily conducted by the vanquished, would, wherever the king was concerned, retain the language of despotism: And in this way, likewise, as the conquerors would, at their first settlement, have more lands than they could well occupy, the greater part of the imperial fiefs (those vast domains which monopolized the Roman provinces) would remain to the king: And, without doubt, the right of distributing the lands at the sojourning of the tribe, which was the known and ancient prerogative of the German chiefs, would greatly facilitate his acquisition of the fiefs, without envy or dispute. Thus the king would become the most considerable proprietor in the nation, and his vast possessions would enable him to multiply exceedingly the ancient numbers of his retainers, and to afford them, in return for their services, more valuable rewards than the battle-horse, or the conquering spear.

THE retainers of the subordinate chiefs would, in like manner, be multiplied and rewarded with lands. Under the empire, the municipia, as well as the emperor, had their proper domains, from the produce of which they defrayed the public expences of the community. Besides these domains, there were

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large commons allotted for the promiscuous use of the inhabitants of particular districts; and the devastations of the conquest left large tracts of land destitute of proprietors. Now, independently of the grants which the subordinate chiefs might spare from their own large estates, they must evidently have had great influence in the disposal of such public, common or waste lands. Possessed of the prerogative of distributing the lots of the citizens; inheriting, for the most part, a considerable family-interest, which the wealth of the conquest had confirmed; entrusted, in the first instance, with the care of the public treasure and the public safety, and free from the jealous factions of an independent state, it must soon have become a matter of course for them to make grants of such lands to their favourites and retainers*. The conditions of the grants were, no doubt, various. Some, we know, were like the lots of the citizens conferred in full property; but, among people who had acquired wealth by conquest, before either laws or government were ripe to guard it, the natural and ordinary terms of all such transactions must have been military service, yielded on the one hand, and lands and protection conferred in return. These grants were termed benefices, and the grantees beneficiaries; and, in this way, a great number of the more enterprising and better sort of people were not only distinguished, as before the conquest, by their particular attachment and fidelity to certain chiefs, but came to be subjected to the specific obligation of yielding to the king, or to other great men, an extent of military service, much beyond what they owed to their country, in common with the rest of the nation.

BUT however much this practice may have added to the powers of the magistracy, or whatever revolutions in government it afterwards produced, there is no reason to imagine, that, in
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* In Sweden, the towns, hundreds, and provinces had each of them commons, bearing respectively the technical names of *lamfalt*, *haradzalmaining*, and *land almaining*, grants of which were obtained from the chief magistrates, *viz.* *lagman*, *hereda*, &c.; and such public and common lands are natural appendages to all rude communities.

early times, it affected, in any shape, the structure of the legislature. As attendance around their chiefs at the national assemblies was a condition by which benefices were held, the beneficiaries would be more punctual than others in frequenting the diets; but it is not to be thought, that, on such occasions, the royal beneficiaries were either admitted into the council of the king and chiefs of *pagi*, or deliberated apart from other freemen.

I LIKEWISE apprehend that there is no sufficient reason for conceiving, that either the acquisition of the Roman towns by the conquest, or the embracing of Christianity after it, would make any material innovation in the form of the original German legislature. The government of the Roman towns was well suited to combine with the German political arrangements. Most of them had, in fact, been originally *pagi* *, and still retained vestiges of their primary structure; and those that had been founded in civilized times were, modelled after Rome, herself unquestionably a production of rude ages. The curiales, or ancient burghesses, were every where arranged into wards or tithings under headsmen elected by them, called *decuriones*. The curiales formed a popular assembly; the *decuriones* a senate. Magistrates chosen by them, and holding their offices for a limited time, exercised a subordinate jurisdiction; and, like those of Rome, judges, selected from the order of *decuriones*, tried law-suits. Besides, each considerable town usually chose a great man to be its protector and patron, and was likewise subjected to one or more magistrates, invested with military and civil powers, and appointed by the emperor.

NOTHING, then, could be more natural than that the municipia should, immediately on the conquest, acquire the aspect of the German *pagi*. The new settlers naturally mixed with

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* THERE were above an hundred sovereign states in Gaul, and many more in Spain, when subdued by the Romans; and there were 115 free cities in Gaul under the empire.

the curiales, transacted the affairs of the community, and yielded military service, under their tithing men or decuriones, led by a common chief, called a *graff*, *burgraff*, or *count*, in the same way as the inhabitants of the country districts.

THE conversion to Christianity was, however, an event that, though it created no change in the general structure of the legislature, must have naturally augmented the numbers of the deliberative body which presided in it. As Christianity incapacitated the leaders of tribes from officiating as chief priests at those religious rites which were usually celebrated at the opening of public assemblies, the bishops and abbots came naturally to discharge this duty on such occasions. In this way, they must have shared in the rank, by sharing in the functions of the chief; and the situation in which they thus appeared at the opening of all political conventions, would enable them to join, with much effect, in the deliberations which ensued; and their superior knowledge, their sacred character, and their influence with the people, would soon acquire them power equal to their rank. They must, therefore, have been well entitled to demand admission into that council, which was formed by the king and the lay chiefs at the national assemblies; and, as they balanced the authority of those chiefs, we cannot doubt, that the king would be disposed to give the utmost effect to their claim. Accordingly, we every where find the dignified clergy presiding along with the lay magistrates, in the provincial assemblies of every degree in all the Gothic nations, and enjoying every advantage, in point of rank and authority, in their national diets.—As to the inferior clergy, they must long have continued blended with the body of the freemen. It was by degrees only that ecclesiastics were at first exempted, and afterwards prohibited from yielding military service; and we may be sure, that, in a rude age, the clerical character must be unable to extinguish suddenly that of the warrior.

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THE leading proposition in the foregoing hypothesis is, that the diets of the European states were originally national assemblies, containing, *de jure*, the whole warriors belonging to them, conducted by their local chiefs or magistrates, who, together with the king and dignified ecclesiastics, formed a senate or council that, in general, directed the common resolves. I propose, in this part of the paper, to consider the grounds of this proposition, in the first place; and then, chiefly with a view to our own country, examine the evidence relative to the deliberative council which I have ascribed to the diets, and to the situation of towns, in order to justify the hypothesis, in stating that the former was an assembly of the magistracy, and that the latter resorted to the diets, in the same manner as the country districts.

CONSIDERING how certainly we know, that the warriors or *liberi homines* of every tithing and hundred were bound to attend personally, not only on the meetings of these districts, but in the general meetings of the province or shire, where they not only were reviewed by the chief magistrate, but assisted in the judicial and political deliberations which the business of their quarter required, it might have been imagined, that a natural analogy would have led authors to agree in the supposition, that the national diet was nothing more than an aggregate of the provincial diets, in the same manner as the provincial diets were aggregates of those of lesser districts. The difficulty we feel in accommodating our reasonings to a period, when both the business and the amusement of a freeman consisted in making war, and when the habits of the migratory life of shepherd tribes were still recent, and rendered the manners of society extremely different from our own, is the only reason I can offer for this opinion having met with little attention or regard. Strong arguments in favour of it, from the history of the ancient German nations, I flatter myself, will be suggested from what has been stated in the former parts of this paper. Those
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from the history of latter times, I hope, will be found equally satisfactory.

WE have no details respecting the diets on the continent, previous to the rise of the house of Martel. GREGORY of Tours, in a passage formerly quoted, mentions the Franks assembling in their *champ de mars* "per phalanges *;" in other places, he calls their national council an *exercitus*; and we have frequent mention of similar conventions †, before as well as after DAGOBERT I. when the power of the mayors of the palace came to engross that of the crown. The *champs de mars* were fields belonging to the great cities of Gaul, allotted for the recreation of the inhabitants, and named after the *campus martius* in Rome. And, as the assemblies of citizens and reviews of the troops were held in them, it was natural they should likewise be chosen for the meetings of the diets of the Franks, whether general or provincial. We usually find mention made of these assemblies as celebrated

* Thus he mentions a placitum, in which GONTRAN appointed CHILDEBERT the heir of his kingdoms; and tells, that there "GONTRAN cohortabatur omnem exercitum," and feasted them for three days. *Lib. 7. § 33.* In the same way, when CLOTAIRE marched against the Saxons, and they offered terms of accommodation, which the king approved of, and proposed to his people, he relates, that they (Franci) repeatedly rejected them; and when CLOTAIRE declared to them, "Si abire volueritis, spontanea voluntate non sequar," that "ipsum vi detrahentes interficere voluerunt, si cum illis abire diceret." *Lib. 4. § 14.* See also *lib. 6. § 45.* An ancient author writes, "Francorum regibus moris erat kal. Maii, præsidere coram tota gente, et salutare et salutari, obsequia et dona accipere. SIGEBERT ad ann. 662 pontan. orig. Franc." *Lib. 6. p. 485.*

† WHEN, in A. D. 575, SIGEBERT wanted to dethrone his brother CHILPERIC, he was assassinated by two *pueros Tarvuanenses*, who had been hired by the wife of CHILPERIC, and assisted at his election to the throne with this view. The election was like that of CLOVIS, by the nation assembled. "Collectus est ad eum omnis exercitus, impositumque supra clypeum, regem eum super se statuunt: — dixitque Fredegundis (*sciz. pueris.*) "Ite ad cuneum SIGEBERTI, et adsimulate ut eum supra vos in regem elevare debeatis." *Gesta Francor. § 32.*; and GREG. *lib. 4. § 46.* When, about A. D. 612, THEUDEBERT claimed ALSACE from THIERRI, the historian relates, "Unde placitum inter hos duos reges ut Francorum judicio finiretur in Saloisso (*Seltz.*) castro instituunt. Ibique THEUDERICUS (or THIERRI) cum SCARITIS tantum decem millibus accessit, THEUDEBERTUS vero cum magno exercitu Austrasiorum." *Fredeg. Chron. § 37.* When BRUNEHAUT, the JEZEBEL of the North, was put to death by CLOTAIRE, it was "advocato agmine Francorum et Burgundiorum, et omnibus vociferantibus Brunihildum morte turpissima esse condignam." *Gesta Francor. § 40.* Again; "Cum autem denunciatum fuit placitum qua die ad præliandum convenire deberent." § 30.

celebrated in the spring, previous to a military expedition ; to which, I apprehend, they, in the same manner as in the most ancient times, were a necessary prelude *. On these occasions, the name of *placitum exercitale* is often ascribed to them, while the term *placitum* simply is attributed to all diets without exception, where judicative and political authority was exercised. This circumstance itself looks as if these assemblies had differed only in their object. The power and means of convoking them, and the persons that they consisted of, must have been the same in both ; and, without deliberative powers, we cannot conceive any thing more absurd than to have bestowed the name of *placitum* on an assembly of the national force.

BUT, though we have no particular description of the Merovingian placita, or malla †, we find every where evidence, that all affairs of consequence were transacted in them. The mayor of the palace was chosen in them ‡; differences among the royal family, and with foreign nations, were decided in them ||; and the Salic law seems to have owed to them its sanction §.

UNDER

* See PEPIN'S Expedition to Italy. *Fredeg. Chron. Contin.*

† MAEL, in German, an assembly or convivium.

‡ *Fredeg. Chron. cap. 43. et 89.* And, I apprehend, the kings themselves likewise. In a dispute between CLOTAIRE II. and the children of THIERRI, CLOTAIRE makes this reply to an embassy from the latter : "*Judicio Francorum electo, quicquid precedente domino a Francis inter eosdem judicabitur, pollicetur se implere.*" *Ibid.* § 40. In the same way, the constant expression used in the Chronicles to record a succession to the crown, is, "*Et filium ejus Franci super se regem statuunt.*" *Gest. Franc.* § 43. The very ceremony of the coronation of the French kings, as practised in modern times, is that of an election by the grandees, assembled within the church of Rheims, and an approbation of the people assembled without. In fact, however, the Chronicles often mention elections in express terms.

|| Thus AISTULFUS, king of the Lombards, engaged, "*Ut omnia per judicium Francorum emendaret ;*" and it was "*per sacerdotes et optimates Francorum,*" that he obtained peace. *Fredeg. Chron. Continuat.* In the same way, "*GUNTRAN et CHILPERIC pacem fecerunt, pollicentes alter alterutrum, ut quicquid sacerdotes vel seniores populi judicarent, pars parti componeret quæ terminum legis excefferat.*" *GREG. Tur. lib. 6. § 31.*

§ In the preamble of the compilation of it, as corrected under CLOTAIRE II. the authority it proceeded from is thus described : "*Temporibus CLOTARII regis, una cum principibus*"

UNDER the Carolingians, we have much more particular accounts of these assemblies. The most unambiguous expressions of historians indicate that they were national*.

HINCMAR relates, that, at the placita, the "Episcopi abbates, "vel hujusmodi honorificentiores clerici, sibimet honorificabiliter "a cætera multitudine primo mane segregarentur;" and that a similar separation took place, as to the comites, "vel hujusmodi "principes." These, he says, formed two councils, which met together in one, when the affairs under deliberation required it. Here, then, we have the magistracy, or governors of towns and counties, and the dignified clergy, forming a senate, and separated from the multitude of which the rest of the diet was composed. And it will be particularly observed, that this multitude were, by no means, as has often been pretended, a rabble of attendants and spectators; for it is related, that no "inferiores personæ" were admitted among them; and that their functions were to hear the resolves of the lay and ecclesiastical magistracy; and sometimes (in cases, I suppose, of very general interest) deliberate on them, and confirm them, not by their power in executing them, but by their suffrage in approving of them †.—There is also a lesser diet mentioned by

HINCMAR,

"principibus suis, id sunt, 33 episcopis, 34 ducibus, et 79 comitibus, vel cætero populo "constituta est." And HINCMAR, archbishop of Rheims, under LOUIS LE DEBONNAIRE, a well informed author, and anxious to preserve information of the constitution of his country, seems to hold it as a thing perfectly notorious, that, in all times, the national consent had been given to the promulgation of laws. "Habent enim reges," says he, "et reipublicæ ministri, leges quibus, in quacunque provincia degentes regere debent "habent capitula Christianorum regum, ac progenitorum suorum, quæ generali consen- "su fidelium suorum tenere legaliter promulgaverunt." *Vol. ii. p. 204.* The capitularies are express on this subject. One of them runs as follows: "Per capitula avi et pa- "tris nostri, quæ Franci pro lege tenenda judicaverunt et fideles nostri, in generali pla- "cito nostro conservanda decreverunt." *Capit. Carol. Cal. tit. 39. cap. 8.*

* It is related under the year 767, "Ibi synodicum fecit (sciz. PIPINUS) cum omnibus Francis in campo Bertini. *Annales Francor.*

† It is thus I understand the following passage. It begins with mentioning, that there were two diets in the year, one of the general kind I am treating of, in which the whole

HINCMAR, which, he says, consisted only of the *seniores* and *præcipui conciliarii*, i. e. "the magistracy and principal officers of the crown," and was destined for the purpose of making presents to the king, and consulting on such affairs respecting the business of the ensuing year, as required early deliberation.

OF this period, as well as the former, it is also to be remarked, that we find the term *placitum* applied indiscriminately to the assembly summoned for immediate war, and to that where deliberation rather than action was its object*.

THE ancient German diet, under the houses of Saxony and Franconia seems to have retained precisely the form which HINCMAR ascribes to it under CHARLEMAGNE. At the election of CONRAD II. A. D. 1024, we find the nation assembling in the plains between Worms and Mentz; the Franks on the west, the Saxons, Carinthians, and Bavarians, on the east. The dignified clergy, and the dukes, counts, and marquisses, retired to an island on the Rhine, and agreed, that two persons, named CONRAD, should be the candidates. The archbishop of Mentz proposed the eldest first. The dignified clergy gave him their suffrages, then the dignified laymen, and, in fine, the multitude of the nobility, distributed into national battalions, gave their consent by cries and acclamations†. PFEFFEL, vol. i. p. 180.

I NEED scarce observe, that this form of the diet under the house of MARTEL affords the strongest indication of its form under that of CLOVIS; for it is clear from the Capitularies, that the feus had

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whole business of the year was arranged, so as not to be altered: "Nisi summa necessitas quæ toto regno incumberebat;" and thus proceeds, "In quo placito generalitas universonum majorum, tam clericorum quam laicorum, conveniebat; seniores, propter concilium ordinandum; minores, propter idem concilium suscipiendum et interdum pariter tractandum, et non ex potestate, sed ex proprio mentis intellectu vel sententia confirmandum." Vol. 2. p. 211.

* SEE passage in the preceding note, as an example of the latter; and for the former, see *Capit. passim*. Thus, *cap. 2. Car. Mag. cap. 9.* where the bishops, counts and abbots are required to have people, "Qui, &c. ad diem denunciati placiti veniant, et ibi offendant quomodo sint parati. Habeant loricas vel galeas et temporalem hostem."

† THE election of LOTHARIUS II. A. D. 1125, was decided against the inclination of the senate, by the will of the multitude, of which, as the accurate PFEFFEL observes,

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not as yet affected the general structure of the legislature; and we know of no other source from which any great change in it could have proceeded. Besides, the form of the Polish diet coincides so exactly with that above described, while Poland, at the same time, was never feudalized, as greatly strengthens the conclusion, that it preserved much of the original structure of the European diets; especially as the singular tenaciousness of the Poles to ancient customs, and their seclusion from many of the sources of political innovations, render it otherwise highly probable, that they must retain more of the arrangements of ancient Europe than are to be found in other nations. In the diet of Poland, the senate, consisting of the bishops, and of the provincial magistrates, palatines, and castellans, *i. e.* governors of counties or fortresses, assemble within an inclosure, called the *szopa*. The king presides, and, in his absence, or during an interregnum, the archbishop of Gnesna. The noblesse are arranged without, under the banners of their palatinates, and approve, or reject, by exclamations, such propositions as the senate think proper to make to them *. And it is to be remarked, that descent alone, without any estate in land, is sufficient to constitute a person a member, either of the provincial or national diets †.

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“ Les historiens font monter le nombre à plus de soixante mille hommes, tous rangés sous leurs drapeaux et divisés en six brigades.” *Vol. I. p. 242.*

* INSTEAD of the noblesse of the palatinates in the ordinary diets, only deputies attend; but this is known to be merely a modern invention, and that still it is competent to assemble the whole body of the nobility, which is actually done when a *comitia paludata*, or an assembly more destined for action than deliberation is convoked.

† THE account SHERNHOOK gives of the ancient Swedish diet shows, that it was also a national assembly of confederate tribes arranged by the districts to which they belonged: “ *Hæ provinciæ*,” says he, “ *parvum quoddam reipublicæ corpus sibi fecisse videntur, non alias in communi cum reliquis consulentes, quam cum aut de hoste pelendo, aut rege eligendo vel sustentando ageretur: Non enim ut hodie separati ordines erant sed provinciæ; ubi mixti nobiles, clerici, cives, milites, rustici provinciatim, et pro communi habitationis loco responderent: Quod et antea dictum est, et inter se ordines magis quam provincias conjunxit.*” *P. 47.* As to the term *rustici*, it may be observed, that only the peasants of the domains send the representatives which form the house of peasants in the modern diet. The crown continuing elective, they had become freemen and proprietors in early times.

WHAT we know of the Spanish diets before the invasion of the Saracens, is also agreeable to the same notions of the ancient legislatures. We have evidence, that both the grandes and the populace gave their suffrages at the elections of the Gothic kings*. It is certain, that their cortes, or councils, were attended by the dignified clergy, and by the palatines, or great provincial magistrates, comprehending *duces, comites et gardingi*, who had the right of summoning and leading forth the national militia†. We have likewise evidence, that this militia, when in actual service, formed occasionally what might be called a *placitum exercitale*‡. It seems highly probable, therefore, that this militia likewise attended the cortes, which we find always accompanied with a multitude, to whom the resolutions of the deliberative body of it were communicated for approbation ||; a circum-

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* In the history of the election and expedition of WAMBA into Gaul, published by an archbishop of Toledo, it is not only said of him, "Quem totius gentis et patriæ communio elegit," and that at his election "Populi acclamatio extitit," but also that he had the "anhelantia plebium vota;" and that a duke, by menaces, compelled him to accept of the crown. *Apud du Chesne, vol. 1.*

† *Vide* L. L. Visigoth. et Concil. Tolet. Can. passim.

‡ WE have a very curious record of the trial and judgment of PAULUS, and his associates, for revolting in Narbonne against WAMBA, in A. D. 673. It bears, that, after they were vanquished and taken captive, "Convocatis adunatisque omnibus nobis, itidem senioribus cunctis palatii, Gardingis omnibus, omnique palatino officio, seu etiam adstante exercitu universo in conspectu gloriosissimi nostri domini, PAULUS cum prædictis fociis suis judicandus assistebat." It does not certainly appear who the *nobis omnibus* were, for there are no subscriptions preserved; but, I imagine, the enumeration which succeeds that expression is the true interpretation of it. Accordingly, sentence seems to have been pronounced by the whole assembly, "Ob hoc secundum latæ legis edicta, hoc omnes communi definivimus sententia." The punishment was "mors turpissima," with a reservation, that the king might spare their lives, "Sed non aliter quam evulsis luminibus." The proceedings at the trial are highly curious. The king first asked the rebels if he had done them any injury. They confessed he had not. Then the record of their having joined in the king's election, and sworn fealty to him, authenticated by their subscriptions, was produced. Then followed the record of PAULUS having accepted of their fealty; and, in fine, two laws of the councils of Toledo against rebellion were read. The first of these steps was probably necessary, because the Gothic kings at their election "fidem populis reddiderant." *Apud du Chesne, vol. 1. p. 831.*

|| E. G. THE speech of St LEANDER, when the cortes renounced Arianism, in the reign of RECAREDO, in the end of the sixth century.

stance which well explains why, on a vacancy of the throne, after a successor was named by the palatines, it was always esteemed necessary to assemble a solemn diet, in order to have their appointment confirmed, and the right of the new king recognized by the nation.

If we turn our researches more homeward, we shall find, that every thing, in the like manner, indicates, that the legislature was a national assembly.

THE very places of meeting, in the open air, and in great plains afford reason to suppose, that the diets of the Anglo-saxons were very popular assemblies; and all the expressions of historians, in mentioning them, likewise establish that such was the fact *. Even after the conquest, the English diets were still at times very numerous. In an assembly under WILLIAM RUFUS, *A. D.* 1094, almost all the nobility of England are said to have been present †; and it appears, that, besides them and the dignified clergy, a great crowd of both clergy and laity attended; and that a miles, *unus de multitudine*, made a speech, encouraging Archbishop ANSELM in the conduct he was pursuing ‡. Accordingly, even the laws of the Conqueror bear to have been enacted, “*Per commune concilium totius regni* ||.” And the
ancient

* THE council, or diet, in which EDGAR was to be absolved from penance, in *A. D.* 973, is described thus: “*Adunatis episcopis, abbatibus, et cæteris principibus, cum tota regni ingenuitate, coram eis adstante innumera populi multitudine.*” The council of *A. D.* 697, assembled at Berghamsted, enacted sundry laws, or canons, which bear that they were decreed by the clergy; “*Viris utique militaribus et communi omnium consensu.*” Earl GODWIN purged himself of the murder of the king’s brother ALFRED, “*coram rege et universa gente.*” *Saxon Chron.* 1052. MATTHEW of Westminster says, “*Maxima pars regni, tam clericorum quam laicorum, in unum congregati pari consensu KNUTONEM in regem elegerunt.*” The Saxon Chronicle relates, that, on HAROLD’s death, “*Populus universus elegit EDWARDUM in regem.*”

† EADMERUS calls it simply, “*totius regni adunatio.*” *P.* 39.

‡ *Ibid.* p. 26.

§ THE election of the dignified clergy was anciently in parliament; and I see a record in Madox, where STEPHEN, in vesting the bishop of Bath with the temporalities of his

ancient entry in the journals of the House of Lords suggests the idea of the nation having been assembled along with them: "Præfente etiam *toto populo, et plebe de domo communi.*" The last words, *et plebe de domo communi*, must evidently have been added after the admission of the representatives of trading incorporations among the milites, or proper citizens of the nation.

WE also find the same indiscriminate application of the diet to civil and military purposes as in the continent. So low down as 23d HENRY II. *A. D.* 1177, mention is made of an extraordinary parliament being assembled at Windsor, attended by all the earls, barons, and almost the whole military tenants of the king, with their horses and arms, prepared to go wherever he should command them*.

IN Scotland, also, we have full evidence of the ancient diets being a national assembly. BENEDICTUS Abbas, under the year 1188, mentions, That the bishop of Durham, and others, were sent by HENRY II. to WILLIAM, king of Scotland, to collect tithes: That WILLIAM, being desirous to get back certain castles that had been taken from him, agreed, provided the consent of his subjects could be obtained: That the ambassadors came accordingly, "In LEONEIS ad locum quæ dicitur Brigeam; — et ipse rex Scotorum, cum omnibus fere episcopis et comitibus et baronibus terræ suæ, et cum infinita hominum suorum multitudine, ad locum præfixum venerunt; et audita adventus nunciorum regis causa, et eorum petitione, "habito

his see, addresses the grant, "Archiepiscopis, episcopis, abbatibus, comitibus, baronibus, et omnibus fidelibus, per totam Angliam, constitutis;" and adds, that the grant proceeded, "Canonica prius electione præcedente, et communi vestro concilio, voto et favore prosequente." This charter is tested in a general council at Westminster; "Audientibus et collaudantibus omnibus fidelibus," &c.

* BENEDICT. Abb. apud LITTELTON, HEN. II. vol. 3. p. 290. Even under HENRY III. *an.* 1223, "Natali domini," says the Chronicle of Dunstaple, "venit rex Northampton, et cum eo D. Cant. archiepiscopus, et tot episcopi, et comites et barones, et milites armati, quod nec in diebus patris sui, nec postea, dignoscitur tale festum in Anglia celebratum." *Ap. Hody, p.* 300. See also note below, on p. 150.

“habito cum suis concilio, respondit, se non posse animos eorum inclinare ad decimam dandam. Et ipsi pro se responderunt, se nunquam decimam duros; nec etiam si rex Angliæ, et dominus eorum, rex Scotiæ, jurassent se illam habituros, unquam illam darent*.” In the laws of WILLIAM, we find some introduced as follows: “Assisa regis WILLIELMI facta apud Perth, quam episcopi, abbates, comites, barones, thani, et tota communitas regni tenere firmiter juraverunt,” &c. †. “Statuit rex WILLIELMUS apud Sconam, de communi concilio et deliberatione prælatorum, comitum, et baronum, ac libere tenentium,” &c. ‡. Nothing, however, is extant which communicates more satisfactory evidence of the ancient diet being an assembly of the nation, than the indenture entered into between ROBERT BRUCE and his people, in the year 1326. It proceeds on the narrative, that the king, holding his full parliament, where were assembled the earls, barons, burgesses, and all the other freeholders of his kingdom, made a proposal to them, which they approved of, and the persons approving are enumerated in the following explicit manner: “Qui omnes et singuli comites, barones, burgenfes, et libere tenentes, tam infra libertates quam extra, de domino rege, vel quibuscunque aliis dominis infra regnum, mediatè vel immediatè tenentes, cujuscunque fuerint conditionis ||, confidentes et fatentes præmissa esse vera, &c. habito super præmissis communi ac diligenti tractatu, &c. unanimiter concesserunt,” &c. §. This very curious record, the original of which

* Vol. 2. p. 515.

† Cap. 7. See also general title.

‡ Cap. 32.

|| THE ecclesiastics seem to have been omitted in this enumeration, because the grant in agitation regarded only laymen. In the parliament, or assembly of the states at Ayr, A. D. 1315, where the settlement of the crown was made on ROBERT I. the enumeration is as follows: “Episcopi, abbates, priores decani, archidiaconi, et cæteri ecclesiarum prælati, comites, barones, et cæteri de communitate regni Scotiæ, tam clerici quam laici.” *Ap. ANDERSON’S Independence, Appendix, No. 24.*

§ THE diet which HENRY I. of England summoned in 1115 or 1116, to recognize the succession of his son WILLIAM, seems to have contained vassals of subjects. MALMSBURY says,

which is still extant in the Advocates Library, proves, that, notwithstanding the feudal subordination which was then taking deep root in Scotland, the lowest military tenants in the kingdom assembled in the national diet, and still retained so much of their *original independence*, as to exercise a right of suffrage there, in common with their feudal superiors *. I express myself in this manner, because, I imagine, every person acquainted with the history of the progress of society, or with the genius of the feudal system, must perceive, that the admission of vassals to the exercise of any of the functions of sovereignty, in common with their lords, under the predominancy of that system, could never have been the result of it, but must have been the remaining effect of a situation of things anterior to that inequality which the feudal arrangements of landed property had introduced or confirmed.

THIS principle, likewise, leads me to observe, that the history of the representation in parliament of the counties, whether in Scotland or England, does, in fact, contain evidence, that the freeholders in both were originally members of that legislature, from attendance on which they were excused, only on condition of conveying their powers to delegates officiating in their stead.

In

says, " Ei (*viz.* WILLIAM) vix dum 12 annorum esset, omnes liberi homines Angliæ et Normanniæ, cujuscunque ordinis et dignitatis, *cujuscunque domini fideles*, manibus et sacramento se dedere coacti sunt." See HODG, p. 198.

* THE *iter justiciarii* proves, that subvassals were anciently sectatores of the king's court: " Primo vocentur sectatores, et eorum domini; quia tametsi sectatores comparent, tamen eorum domini obligantur ad comparendum, coram justiciario in suo itinere." Again; " Sectatores curiæ iterum vocari debent singuli bis, cum ipsorum dominis." It appears, too, from *cap. 15. Quon. Att.* That a vassal of a baron was probably, at the period of the regulation there mentioned, still a sectator curiæ vicecomitis. Possibly, *cap. 67. ejusd.* may have been the origin of their being excluded the county courts of freeholders. It is there provided, that a baron cannot be judged by a vavasor, nor a vavasor by a burgess; but that a lower person might be judged by a higher. In the decline of the feus again, *viz.* in 1593, all landed men were found by the court of session to be pares curiæ, and competent to sit as jurymen, even in the trial of peers before the justiciar. MACK. *Crim. part. 2. tit. 8.*

In Scotland, we know, that it was not till the latter part of the sixteenth century, that freeholders were excluded from sitting along with their representatives; and though, during the period of domestic troubles that occurred between the reigns of ROBERT I. and JAMES I. the feebleness of the crown appears to have permitted such an usurpation of sovereignty in the subject superiors, as to deprive their military vassals of the title and rights of freeholders, the indenture I have quoted proves that they originally possessed them. And the analogy of England, where they never lost them*, but retain, at this day, the name and privileges of freeholders, in common with the tenants *in capite*, confirms powerfully the evidence which that indenture affords.

It may further be remarked, as a circumstance extremely favourable to the hypothesis I have offered, not only that all freeholders owed military service, but that, in Saxon times, the *expeditio militaris* formed an article of the trinoda necessitas incumbent

* I KNOW English antiquaries suppose there was a time when the vassals of subjects were admitted to the privileges of freeholders. But there is no vestige of evidence that such an event ever took place, or that there was room for it, by their ever having been destitute of those privileges. The fact, I apprehend, was, that the vigorous administration of the Anglo-Norman princes prevented, in a great measure, that usurpation of sovereignty in the subject superiors, which occurred in other countries. Hence, though property was arranged in England according to feudal ideas, the vassal preserved much of his public privileges and natural equality as a citizen. Thus the *valvasor*, or powerful vassal of a feudal lord, was regarded as a superior person to a simple *miles*, or petty tenant *in capite*. Thus, the sheriff alone could levy a distress from vassals, to compel them to fulfil their obligations to their superiors. Thus the first peer of the realm is not only, in all civil cases, subject to the jurisdiction of a jury of commoners, who may be vassals of subjects, but, in criminal cases, is subject to the grand jury, and, on an appeal of felony or murder, may be convicted capitally by a petty jury of them. And thus, too, the king always might have required the council of any freeholder, by writ, commanding his attendance in parliament, where he consequently might have sat and voted as an equal with his feudal lord. The statute HEN. III. *an. 9. cap. 14.* seems to have arisen from the distinction of ranks which the feudal law had then rivetted. In the mandamus of that prince to the itinerant justices, he directs them to amerce all liable to be amerced, except earls and barons, "*Qui coram concilio nostro amerciandi sunt.*" By § 27. *Mag. Chart.* they could be amerced only "*per pares suos.*"

cumbent on every free citizen, and that the possession of a sword and a lance was such a characteristic of freedom, that the ceremony of emancipating a villein consisted in bestowing them on him.

I DO not mean to contend, that every degree of emancipation, though creating an obligation to serve in war, conferred a right of entry into the courts of the hundred and shire. I rather incline to believe, that, in general, the emancipated remained subject to various burdens in favour of their patrons, and resorted to that domestic jurisdiction which their patrons exercised in their own domains; and that, in turbulent times, many of the original freemen were either compelled by their more powerful neighbours, or found it convenient, for the sake of protection, to submit to similar burdens, and to a similar degradation. But, on the other hand, we find the Saxon Ceorls entering into *sodalitia* with the most considerable persons in the state: We find sokemen, in the oldest times, members of the county-courts; and Doomsday proves, that even those sokemen, who probably had no entry there, and were transferable by their lords, retained so much of the characters of the ancient independence of freemen, that they exercised the functions of suitors of courts, and were capable of enjoying the emoluments of jurisdiction*.

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FROM

* IN enumerating the lands of ROGERUS comes, it is said in Doomsday-book; "Hanc terram tenuerunt 6 soccomanni, et dare et vendere terram suam potuerunt. Unus eorum homo regis EDWARDI fuit, et Invuardam invenit vicecomiti. Tres istorum Soccomannorum accommodavit PICOTUS (the vicecomes), ROGERIO comiti, *propter placita sua tenenda*. Sed postea occupaverunt eos, homines comitis et retinuerunt cum terris suis sine liberatione, et rex inde servitium non habuit, nec habet. Sic ipse vicecomes dicit." P. 193. 2. Again, when describing Herstingestan hundred; "Ibi est terra Soccomannorum 5 hid. ad geld. Terra 8 carruc. et 6 bov. Isti soccomanni dicunt, se habuisse levitatem, blodevitam, latrocinium suum, usque ad 4 denar. et post 4 denar. habebat abbas forisfacturam latrocinii." In the remarks at the end of the survey of the shire, it is said, that a jury informed that, as to these 5 hides, "Terra soccomannorum fuit tempore regis EDWARDI; sed idem rex dedit terram et socam de eis sancto Benedicto de RAMSEY, propter unum servitium quod abbas ALVINUS fecit ei in Saxonia, et postea semper habuit." *Huntingtonshire*.

FROM all this combined evidence, derived from the history of so many countries, I think myself entitled to conclude, that the European diets were, in their origin, national assemblies of the warriors of each country, in the same manner as the provincial diets consisted of the *posse comitatus*, or military force of each district. I am aware it may be objected, that many of the facts I have founded on are extraordinary events, which, it may be said, ought not to be considered as indicating the true constitution of a country. I think, however, there is a solid answer to this objection. It will be observed, that I am reasoning from occurrences among nations practising agriculture, with a view to discover what constitution they possessed on their first establishment, when war and a pastoral migratory life had formed their opinions and habits. I am, therefore, entitled to suppose, that their ancient and most sacred functions would become unsuitable to their new situation, and be neglected, as inconvenient and burdensome, except when great occasions excited a general interest, which overcame the natural unwieldiness of an agricultural nation, where the powers of government are little felt or acknowledged. In this view, therefore, the examples above quoted, of immense numbers assembling in a military form in the German and British diets, ought not to be considered as insulated events, but as instances marking the genuine structure of the nation: For it will be remarked, that they were not the consequences of revolutions, but only of important occurrences, that must naturally have inclined people to overlook private inconveniences, and, from a regard to the public interest, exert their ancient and known political rights.

I SHALL make only one observation more in favour of my opinion; and it is this, That it fully explains a great variety of circumstances in the history of the middle ages, and, during the reign of the feus, altogether adverse to what was the spirit of those institutions, and the temper of those times. Such are the
the

the formidable and frequent demands made to the Norman princes for the restoration of the Saxon laws ; the regard paid by magna charta to the rights of the commons, as much as of the peerage ; the facility with which deputies from the lesser freeholders were admitted into parliament, so that no cotemporary historians take any notice of the event ; the numerous vestiges of an ancient equality of ranks among those who may justly be termed the warrior cast of the nation * ; the privileges of the noblesse on the continent, and the spirit of the common law in England, so favourable to the rights of the commons and adverse to feudal usurpation : These are a few of the particulars which, I think, have never received any satisfactory explanation on the system of those authors who hold, that all our institutions are to be considered as originating in feudal times.

P A R T II.

SECTION II. *Of the deliberative Body in the Anglo-Saxon and Scottish Diets ; and whether or not they contained Representatives of Towns.*

THERE are two points in the hypothesis maintained in the preceding section that seem to demand separate consideration. These are the members ascribed to the deliberative body in the European diets in general, and in the wittenagemot in particular ; and the denial of any representation having belonged to the commons in the Gothic ages.

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* Thus, in Scotland, where the greater and lesser barons sat together in one house of parliament, we find commoners holding the highest offices in the state, and sitting along with peers in juries and in trials in parliament.

As to the former of these circumstances, it will not have escaped attention, that many of the facts already quoted strongly confirm the general idea, that there was a presiding body in the national diets, consisting chiefly of the ecclesiastical and lay magistracy. HINCMAR's description of the placita under CHARLEMAGNE; what we know of the diets in Germany under his successors, and of those of the Visigoths before the Saracen conquest, and the structure of those of Poland and Sweden, are all agreeable to this opinion. The question, however, who the wites were, from which the Anglo-Saxon diet, or micelmot, derived sometimes the name of *wittenagemot*, has been a matter of so much discussion, the opinion I offer is so adverse to what the greatest of our historians have entertained on the subject, and is itself so material in explaining the origin and functions of the peerage and titled nobility of modern Europe, that I flatter myself some observations, particularly directed to this subject, will not be unacceptable.

In the *first* place, it is to be noticed, that many of the expressions of our ancient historians and records indicate, that the Saxon diet consisted of two bodies. This seems to be implied even in the common enumeration, which begins with the dignified clergy, and ends with some term denoting a great multitude of people, such as *tota ingenuitas*, or *populus*; but there are not wanting more explicit expressions. Thus, WILLIAM of Malmſbury, who flourished only sixty-nine years after the conquest, makes HAROLD, when reproached for assuming the crown contrary to his oath, give the following answer to WILLIAM the Norman: "De regno presumptuosum fuisse, quod
" absque generali *senatus et populi* conventu et edicto, alienam
" illi hæreditatem juraverit," &c. *.

Mr

* ANALOGOUS expressions are used with respect to the diets of the continental nations. As to the northern nations, Poland, Sweden, Denmark, and Norway, the fact, with regard to two bodies, a senate and people, composing their ancient diets, admits of no dispute.

Mr HUME, observing that vast numbers of members were always ascribed to the Saxon diet, has thought it necessary to suppose, that the principal proprietors of land were entitled to seats in it; and he, at the same time, rejects the notion of the commons sitting, or being represented in it, because he finds no mention of representatives in Saxon times; and because, from the nature of the thing, a deliberative council could not contain a whole nation. But, if the diet was a military review, the leaders might naturally form a council far from being too numerous for deliberation; and the body which approved or rejected their resolutions might be supposed to consist of almost any given numbers without confusion. The separation of the diet into two bodies is, no doubt, irreconcilable with Mr HUME's system; but it seems to obviate the difficulties that induced him to adopt it.

In the next place, I apprehend the following passages clearly point out, that the eldest wites, or *sapientes natu majores*, were the lay and ecclesiastical magistrates, and, by no means, merely considerable landholders. INA reigned in Wesssex in the end of the seventh and beginning of the eighth century. His laws are

dispute. As to those of Spain, there seems to be no room for supposing them different: "Tandem unus ex primatibus," says an ancient chronicle, "nomine CHINDASINTHUS, collectis plurimis senatoribus Gothorum, cæteroque populo in regno Spaniæ sublimatur. TOLOGANEM degradatum ad honos CLERICATI tonsorare fecit." FREDEG. § 82. The same constitution among the Lombards seems to be implied in the expression of the chronicle: "Langobardi una cum concilio procerum suorum DESIDERIUM in sedem regni instituunt." DU CHESNE, tit. i. p. 775. As to France, again, under the first Race, we frequently meet with such language as this: "CHILPERICUS rex, convocatis melioribus Francis, reliquisque fidelibus, nuptias celebravit filiæ suæ." GREG. Tur. lib. 6. § 45. "Ille vero congregatis senioribus secum, præparatis epulis," &c. lib. 4. § 27. And FREDEGARIUS writes, "Consilio sapientum usus pagos et civitates, quod fratri suo CHARIBERTO ad transigendum ad instar privato habitu vivendum, potuisset sufficere noscitur concessisse." Cap. 57. In the same way, the legislature of the Saxons, when conquered by CHARLEMAGNE, consisted of a senate and people: "Cum in Saxoniam CAROLUS pervenisset totum perfidæ gentis senatum ac populum, quem ad se venire jusserat, morigeram ac fallaciter sibi devotam invenit." EGINHARTUS in actis ann. 777.

are extant; and the preamble of them bears, that they were enacted with the advice of his father, &c. and the eldest wites of his people. One of these laws provides, that, if any person fights in an alderman's house, or in other (*oþner*) illustrious wite's house, he must pay, &c. Dr HENRY* has translated the passage thus: "If any man fights in an alderman's house, or in the house of one of the famous wise men." It is evident, that here the Doctor makes the passage express a distinction between an alderman and a wite, while the Saxon relative *oþner* manifestly implies, that aldermen were wites, though there were wites that were not aldermen.

ASSERUS, in his life of ALFRED, mentions the attention of that prince to the distribution of justice, and his rebuking his judges for assuming the rank and functions of wites, "Gradus et ministerium sapientum," while they neglected "sapientis studium et operam;" and commanding them, therefore, to lay aside "terrenarum potestatum ministeria." This passage proves, that the wites, or sapientes, were possessed of the powers of magistrates. The sequel of it is, however, still more explicit, and, as I apprehend, obviates every doubt; for, in mentioning the effect of the rebuke, ASSERUS names particularly the persons reformed by it: "Perterriti veluti pro maxima vindicta correcti comites et præpositi ad equitatis discendi studium totis viribus se vertere nitebantur; ita ut mirum in modum illiterati ab infantia comites, pene omnes præpositi ac ministri, literatoriae arte studerent," &c. †.

THESE passages scarce require a commentary. In the law of INA, aldermen are mentioned as a considerable class of wites. The rebuke of ALFRED relates only to laymen; and the sapientes laici are there specified under the Latin names universally used to denote chiefs of counties and towns. The lay wites were certainly, therefore, the chiefs of districts, by whatever name those chiefs were called, heretoges, aldermen, or gerefas:

And

* Hist. of Gr. Brit. vol. 2. p. 246.

† P. 21.

And the ecclesiastical wites, were, without doubt, the dignified clergy whom we find enumerated at the head of those of whom the diets were composed. In the laws of ALFRED, it is said; "Sancti episcopi et sapientes laici statuerunt." KINEWOLF, king of Wessex, in writing about religious affairs, says; "Una cum episcopis meis, nec non cum caterva satraparum;" or, more simply, "Cum consensu episcoporum, atque satraparum meorum." The term *satrap* here, and in other places, used by the Anglo-Saxon writers was certainly, of all others, the most proper to denote those powerful provincial magistrates who were, in fact, petty kings, and united, like them, the civil and military powers. And it will, likewise, be noticed, that this term is used by KINEWOLF, as corresponding to that of sapientes laici in the laws of ALFRED*.

It may be tedious to add further authorities; but I will venture to say, that, if any person takes the trouble to look into the Saxon writers, he will, I believe, find, that the common expressions used by them are more just, if interpreted according to the system I have offered, than in any other way. Thus, for instance, the current phrase, "Confidentibus totius Angliæ senatoribus," or, "Totius Angliæ majoribus natu," could, with no propriety, be used to express, as is manifestly intended by it, that the senate was full and general, unless all the parts of England had senators peculiar to them; that is, that the senators were the provincial magistrates. If they had been either the judges of a royal court of justice, or had been considerable proprietors without functions, then the phrase would naturally have run, "*Omnibus Angliæ senatoribus*," or, "*Omnibus Angliæ*
" *majoribus*

*In the synod of A.D. 694, assembled chiefly on religious affairs, the enumeration of the members is more full; first, the archbishop of Britain and the bishop of Rochester are mentioned, and then it proceeds as follows: "Cæterisque abbatibus, abbatissis, presbyteris, diaconibus, ducibus, satrapis, in unum glomeratis." See also enumeration of the diet which absolved EDGAR, quoted above in note p. 148.

"*majoribus natu confidentibus.*" And many examples of a like nature might be quoted *.

It will naturally occur, that the opinion of a qualification in landed property having been necessary to confer a seat in the wittenagemot, is adverse to the conclusion which is meant to be suggested by the above observations. But it is to be remarked, that what Dr HENRY has laid down on this subject as a matter of certainty, was offered by Mr HUME merely as a conjecture. The only foundation, as far as I know, for this doctrine is a passage in the *Historia Eliensis* †, where mention is made of land being alienated from a convent, in order to make up an estate of 40 hides for a friend of the abbot, that he might be reckoned among the nobles, "*proceres.*" We know, that more anciently a king's thane must have had five hides of land, a chapel and a hall. Hence, as Mr HUME supposed, the great proprietors of land, or king's thanes, were the wites, he conjectured reasonably enough from the above passage, that, in later times, the qualification of a wite had been advanced to 40 hides ‡. It is manifest, however, that, till it is proved that the thanes were *senatores Angliæ*, a doctrine which, by the by, would render the senate too numerous for deliberation, there is no evidence whatever, that a qualification in land had any connection in law with the wittenagemot, farther than that we may conjecture, that proprietors who held lands free from servile conditions alone would be esteemed companions in arms for each other, and

* "*GLORIOSUS rex OFFA cum senatoribus terræ, &c. Hæc decreta senatoribus et ducibus et populo terræ proposuimus.*" SPELMAN'S *Councils*. A charter of EDWARD the Confessor runs thus: "*EDWARDUS R. Salutem dicit HERMANNO episcopo, HAROLDO comiti, et omnibus suis agri Dorsetensis ministris.*" HODY, p. 64.

† Lib. 2. cap. 40.

‡ It is remarked in *Doomsday*, that a thane who had more than six manors in Nottinghamshire, paid 8 pounds relief to the king; but, if he had six or fewer manors, he paid 3 merks to the sheriff, whether he lived in *burgo* or *extra*.

and, of course, alone would attend the provincial and national diets *.

As to Scotland again, there seems to be every reason to believe, that its ancient diet was constituted in a manner very similar to that of the Anglo-Saxons. We find the country divided, like England, into shires and wapontacks. We know, that the Saxons and Danes gave their language and customs to the south-eastern parts of Scotland; and what is transmitted to us of the Irish and Welsh customs seems to differ from the arrangements of the Anglo-Saxons, only as having belonged to a more rude and uncultivated people. On these accounts, I think it reasonable to suppose, that the great men, mentioned in the enumeration of the members of the ancient Scottish diets, were the magistracy of the nation. I know a learned author †, in a late work, seems inclined to dispute that ever earls were official in Scotland. But, so late as the laws of DAVID II. ‡, earls are mentioned as provincial judges; and the ancient Scottish statutes cannot be looked into without finding the term *judices* applied to earls, and others, with the same general impropriety as in the rest of Europe, where it was constantly employed to denote magistrates rather than judges. When, therefore, in an assembly at Perth, fines for non-performance of military service are said to have been ascertained, “Coram rege per omnes judices Scotiæ ||,” we ought to be at no loss to discover, that it was the senators, or the magistracy of the nation, that formed the body here meant §.

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It

* I SHALL afterwards, in considering the innovations in the structure of the ancient legislatures, have occasion to treat of this qualification in land.

† Mr WALLACE.

‡ Cap. 8. and 9.

|| Stat. ALEX. cap. 15. Stat. WILLIEL. cap. 3.

§ It is curious to find GREGORY of Tours using a similar mode of expression, “Post hæc edictum a judicibus datum, ut qui in hac expeditione tardi fuerant damnarentur.” Lib. 7. c. 42.

It is worthy of remark, that the record mentions the fines awarded to have been such as had not been adjudged at the army, where the attendance should have been given. This must be acknowledged to look as if a placitum exercitale was not unknown in Scotland.

I HAVE been able to discover no vestige in Scotland of any particular quantity of land-estate being anciently required to qualify a person to be a member of the national diet. Dr STUART, indeed, has laid it down in his work on the public law of Scotland, that the possession of a knight's fee was necessary for this purpose *; and he has thought proper to treat Dr ROBERTSON with much asperity for holding, that the lesser tenants, *in capite*, were members of it. It does not, however, appear, that even the national force was ever called forth, according to any distribution of the country into knights fees. The statute of WILLIAM the Lion, c. 23. proves the contrary, as far back as his reign. There is, therefore, as little probability as evidence, that this species of estate was employed to form the qualification of a seat in the national diet.

EVEN in England, where knights fees were of such important use, the possession of an entire knight's fee does not appear to have ever been considered as, in the least, connected with a vote in the legislature. By Magna Charta, all tenants *in capite* † were, without distinction, to be summoned to parliament ‡; and, if we look to foreign countries, we shall find, that it was always noble blood alone, or a fee held by a noble tenure, conjoined

* Page 290.

† WHETHER holding by one species of tenure, or another; and whether holding large estates, or only fractions of knights fees. See also L L. GUL. I. and L L. HEN. I. ap. Lambard.

‡ “ ET præterea faciemus summoneri in generali, per vicecomites et ballivos nostros, omnes illos qui de nobis tenent in capite.” *Mag. Chart.* § 14. I must here remark, that this expression is not adverse to my opinion, that freeholders, not holding in chief, were

joined with noble blood, and by no means the quantity of the fee, that afforded a qualification for the diet.

BESIDES, Dr STUART has inserted, in an Appendix to his work, the indenture of ROBERT I. where all the free tenants, "of whatever condition," and whether holding of king or subject, belonging to liberties, or not belonging to them, are mentioned as assembled and deliberating in parliament.

ONE observation more is necessary on the presiding body of the British diets, *viz.* that both in England and Scotland, it appears to have assembled in the same manner as the autumnal placita of the Franks, though no general diet of the nation had been convoked. The Saxon historians often mention assemblies where only senators in general, or, more particularly, bishops, abbots, or seniores, are specified as attending; and we find the Saxon monarchs trying great law suits in such conventions. Thus, says the History of Ely, "Edicetur generale placitum apud Lundoniam," where the duces, principes, fatrapæ, rhetores, and causidici, assembled; and there a question of property was decided by them, in which the bishop of Winchester was concerned*. In the same way, in Scotland, the remains of our

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ancient

were originally entitled to attend at the diets. The tenants *in capite* owed their attendance as the condition of their estates, and were compelled to give it accordingly, while other freemen were more apt to neglect a burdensome and inconvenient duty, which was not, in their case, often enforced by immediate forfeitures. Accordingly, the bold inventor of the treatise Mod. Tenen. Parl. makes the tenants in chief attend parliament by necessity of their tenure, while others only might be asked to attend. The real foundation, however, of this provision in Magna Charta was, I apprehend, no more than this, that the tenants in chief were, agreeably to the feudal arrangements, the leaders and magistrates of their vassals. Hence it was incumbent on the king to summon only his immediate vassals, each of whom was, in virtue of such summons, obliged to attend, "cum hominibus suis." Accordingly we find, that, in Scotland, certain of the vassals owed only presence, and not suit, at the king's courts; and that it was necessary to enforce the obligation of suit by various regulations. *Stat. 1. Rob. I. cap. 2. &c. 4. et 5.*

* Lib. I. cap. 10. See for more such assemblies, *cap. 14. 45. 46. 60.* This piece of history is the more remarkable, that it affords a strong indication of the original independence

ancient laws take notice of ordinances and judgments decreed in fimilar conventions. One GYLASPIC MACSCOLANE we find ordered to give sureties, or surrender himself, by an affembly of all the judices Scotiæ and Galividiæ. A judgment respecting the widows third of lands, rendered by the king in his court, is marked by having been pronounced when many magnates were present, and, therefore, no doubt of the greater authority; and ALEXANDER II. issues ordinances, sometimes "communi confilio comitum fuorum," and sometimes along with the "comites barones et judices Scotiæ;" or, more generally, as in a case formerly quoted, "Recordatio facta coram domino rege per omnes judices Scotiæ †."

* * * *

THE opinion, that the towns had representatives, in the ancient European diets, deserves particular examination, not so much on account of any argument or evidence produced in its favour, as because men of ingenuity have maintained it, and that the discussion of the merits of it tends to throw light on the sources from which this privilege was, in after ages, derived.

AND considering, that the supporters of this opinion generally hold, that the vassals of subjects, and even those tenants *in capite*, whose property was less than a knight's fee, had no place

pendence of the counties. For, after relating the judgment of the generale placitum, it thus proceeds: "Post hæc, infra octavum diem convenerunt iterum ad Northampton, et congregata ibi tota provincia sive vicecomitatu, coram cunctis iterum causam suam prædictam patefecerunt. Qua patefacta ac declarata, ut præjudicatum erat apud Lundoniam, judicaverunt et isti apud Northampton."

† It is natural to consider, as the remains of this ancient institution, the known royal prerogative in England, of holding conventions of peers, though no parliament is in existence; and the practice which appears from the Scots statutes to have obtained in Scotland, of the peers issuing ordinances without the concurrence of the other estates of parliament.

place in the diet * ; and that the representation by knights of the shire in Britain, and deputies of noblesse on the continent, was a modern institution, the æra of which is nearly ascertained ; it surely may be fairly urged, that a hypothesis is, at least, improbable which thus supposes, that, in rude and war-like times, the owners of small estates, who formed so large a portion of the feudal militia, had no access to the national council, while plebeian burghesses had, in all times, been admitted into it, and even, according to some, formed the wites, from which, among the Anglo-Saxons, it derived its name.

BUT though it were permitted us to suppose, that representatives from counties, as well as from towns, had been delegated to the national diets, neither the disorderly and calamitous state of society in the Gothic ages, nor the feudal usurpations to which they gave birth, nor the feeble and disjointed condition in which they left the European nations, can suffer us to attribute to such times an institution which our own experience of it has proved to be the powerful guardian of civil liberty, the surest source of equal and general laws, and the efficacious bond which unites a widely extended country into one great community, cemented by the same public interests, and

* THE Abbé MABLY, however, thinks, that the Commons, or Tiers Etat, formed a third chamber in the diet of the Carolingians, because the *Capit. of A. D. 819, art. 2.* requires *each* comes to bring with him to the diet, “ 12 scabinos, si tanti fuerint, sin autem de melioribus hominibus comitatus suppleat numerum ;” and that the advocati of the dignified clergy should also attend. But the scabini were always chosen “ de nobilioribus ;” and, at any rate, it is evident, the 12 best people of a county can, by no means, be reckoned as of the Tiers Etat. Besides, HINCMAR’s description of the assembly gives no countenance to the notion of a chamber of delegates. The regulation in question, I apprehend, was destined to remedy, in part, that neglect of attendance on the diet, which, at last became so fatal to its authority ; or, perhaps, for some particular purpose, like what we read in Hoveden, of WILLIAM the Conqueror ; “ WILLIELMUS rex, anno quarto regni sui, consilio baronum suorum, fecit “ summonari per universos consules Angliæ *Anglos nobiles et sapientes, et sua lege “ eruditos, ut eorum jura et consuetudines ab ipsis audiret. Electis igitur de singulis “ totius patriæ comitatibus viri duodecim,*” &c. And they are said to have reported the laws upon oath.

and actuated by the same national spirit. It is strange, that those who profess to be the most zealous friends of the House of Commons should adopt a system, according to which a legislature by representatives, even when established among a people uncorrupted by luxury, and trained to arms, proved insufficient to answer the most essential purposes of government. The multiplied oppression, the turbulency of powerful individuals, the national debility, the diversity of local customs, which, it is not to be disputed, were the result, as well as the attendants of the Gothic governments, are surely the strongest evidence of a constitution intrinsically bad, or grossly inadequate to the circumstances of the people to whom it belonged.

BESIDES, if it be considered, that each district had constitutionally the election of its own chief magistrate*, who, it cannot be questioned, was a member of the diet, it will be difficult to conceive, how the measure of sending any other representative to such assemblies should have been adopted. A person with such a character would have appeared to be another

* "AUDIENS autem CHILPERICUS omnia mala, quæ faciebat Leudastes ecclesiis Turo-
nicis et omni populo, ANSUALDUM illuc dirigit. Qui veniens, ad festivitatem Sancti
MARTINI, data nobis et populo optione, EUNOMIUS in comitatum erigitur. Denique Leu-
dastes cernens se remotum," &c. GREG. Tur. lib. 5. § 48. "Præcipientes jubemus,
ut in ipso pago Cenomanico accipere non debeant, ducem aut comitem, nisi per elec-
tionem ipsius pagi, pontificis et pagensium." BOUQUET, tom. 4. ad ann. 698. The
emperor HENRY II. recognized, that it had been the right of the Bavarians, at all
times, to chuse their dukes. Again, "Ut judices, vicedomini, præpositi, advocati, centenarii
boni et veraces, cum comite et populo, eligantur." Capit. ad ann. 809. See also
L L. EDWARDI, cap. 35. and L L. BOIOR. tit. 2. cap. 1. The kings, as presiding ma-
gistrates, had naturally the nomination of dukes and counts; and the people had the
appointment or rejection. The kings seem to have interfered in prejudice of the peo-
ple, by transferring the election into the general assembly of the magistracy, and
then by assuming it altogether. Thus we have frequent mention of the "electiones
de palatio" as to bishops, and they are marked in the edict of CLOTAIRE II.
ann. 615, as an alternative to elections "clero et populo." I have quoted a char-
ter in MADOX, that proves a bishop of Bath was elected in parliament in STEPHEN's
time; and we find dukes and counts sometimes sent "e palatio," and sometimes chosen,
as in the above case of Tours. See also, lib. 8. § 42.

ther chief magistrate, and must have been considered as a rival and a foe to the natural head of the community.

VERY strong arguments have been derived from the progress of the House of Commons to its political consequence ; and, from its rank and functions, when first found acting in the legislature, to show, that it was, by no means, a body coeval with the constitution. These, however, are well known, and need not be insisted on.

BUT, independently of the foregoing observations, which, however they may produce conviction on people accustomed to estimate the force of political reasonings, will possibly be little relished by others ; I apprehend we have evidence of a more direct nature against the antiquity of the representation of towns. *If, previous to the æra of charters of incorporation, towns were governed precisely in the same manner as the country,* it is manifest, that nothing can be more improbable, than that they resorted to the diet in any other way than the rest of the nation ; and an examination of the state of the Anglo-Saxon towns, compared with that of those on the continent, both proves, that *they contained the same orders of persons, and the same political arrangements as the country ;* and even points out the circumstances, in their situation, which led them to exchange their ancient structure for their present constitutions.

IN the *first* place, it is evident from Doomsday, (which, it will be remembered, mentions the state of things under EDWARD the Confessor, as well as their subsequent state under the Conqueror, when the survey was taken), that the towns were universally comprehended under the divisions of the country, by counties, hundreds, and tithings, and were subjected to certain public burdens, in proportion to the division at which they were rated *. And we accordingly find, that,
when

* "BURGUM de Grentbrige pro uno hundret. se defend." *Grentebrescire*. "Bedeford, tempore regis EDWARDI, pro dimidio hundret. se defendeb. et modo facit in expeditione

when the towns, in the succeeding centuries, purchased charters, erecting them into little communities, it was necessary to separate them from the ancient system of subordination to which they belonged. Thus, those charters contained, among other privileges, exemptions from owing suit to the county, and even hundred courts *; exemptions from the ancient authority of the sheriff, as collector of the revenues of the shire; and provisions, that burghesses should not be tried by a jury of the county, unless one half of the jurymen were taken from their corporation. It is scarce necessary to add, that several of the towns which obtained charters were, at the conquest, nothing more than manors belonging to the king, or other great proprietors. ATKYNS, in his *Lex Parliamentaria*, has long ago mentioned several ancient villis of the domain that afterwards became royal boroughs.

2dly, DOOMSDAY exhibits the government of towns as the same with that of the country. Thus, it mentions the comes, vicecomes, and their substitutes, viz. præpositi, majores, &c. as the persons who had authority in towns †: And those that ranked as hundreds are described not only as subdivided into wards

“ expeditione et in navibus.” Of Exon, (Exeter) it is said, “ Serviebat hæc civitas quantum 5 hidæ terræ.” P. 100. “ Huntedun. Burg. defendeb. se ad geld. regis, pro quarta parte Herstingestan hundred.” Of Clifford, it is remarked, “ Istud castellum est de regno Angliæ. Non subiacet alicui hundred. neque in consuetudine. GISLIBET vicecomes tenet illud ad firmam et burgum et carucat.” (village and plowgate), &c. &c.

* In the charter of Portsmouth, RICHARD I. grants; “ Quod prædicta villa, et omnes burghenses in ea, et tenentes de ea, sint quieti — de sciris et hundredis, et de sectis scirarum et hundredorum, et de summis et auxiliis vicecomitum, et servientibus et de placitis et querelis omnibus.” BRADY on Bor. App. p. 14. In the charter of Dunwich, King JOHN grants; “ Quod nullam sectam faciant comitatum vel hundredorum, nisi coram justiciariis nostris: et cum summoniti fuerint esse coram justiciariis, mittant pro se, duodecim legales homines de burgo, qui sint pro omnibus:” And, if they were to be amerced, “ Amercientur per 6 probos homines burgi, et 6 extra burgum.” See others in MADOX Hist. Excheq.

* Of Huntedun, it is said; “ De toto hoc burgo exhib. temp. Reg. Edw. de Landgable 10 lib.; inde comes terciam partem habeb. rex duas, &c.; præter hæc habeb. rex

wards or tithings, but as containing lagmen *, who, we know, were a certain number of the most distinguished persons of a district, named in the assembly of it, in order to enquire into crimes and misdemeanors, and who decided causes on oath, if that mode of trial was preferred to the judgment of the assembly itself. Those towns that belonged to manors were no doubt governed indiscriminately with the rest of the territory of the manors. A manor formed a tithing within itself; and the officers of the proprietor, as præpositus, senescallus, major domo, forestarius, viarius (radman), bedellus, &c.†, by whatever name they

“ rex 20 lib. et comes 10 lib. de firma burgi.” The census of a mill of the burghlands, of 3 piscatores, and 3 monetarii, was divided by the same proportions. “ Burgenſes de Hanton redd. vicecomiti p. ann. 30 lib. et 10 fol. Burgenſes de Grentebrege, T. R. E. accommodabant vicecomiti carucas ſuas, ter in anno; modo novem vicibus exiguntur; nec averas nec car. T. R. E. invenieb. quæ modo faciunt per conſuetud. impositam. Reclamant autem, ſuper Picotum vicecomitem, communem paſturam ſibi per eum ablatam.” Of Hereford T. R. E. “ Si quis burgenſium voluiſſet recedere de civitate, poterat conceſſu præpoſiti domum ſuam vendere, &c. et habebat præpoſitus tertiam denarium hujus venditionis;” and, if a poor man abandoned his houſe, Præpoſitus providebat, ne domus vacua remaneret, et ne rex careret ſervitio” In the ſame city, “ unaquaque maſura” yielded 11 denar. et obol.; and, during 3 days in Auguſt, “ Secabat ad maurdine, et una die erat ad fenum congregandum ubi vicecomes volebat, &c. De hac civitate reddit præpoſitus 12 lib. regi, et 6 lib. comiti.”

* “ In hoc burgo (Grentebriſe) fuerunt decem cuſtodie, &c. De hareta Lagemanorum habuit ipſe picot. (vicecomes of Grentebriſe) 8 lib. et un. palfred, et unius militis arma. ALWRIC GODRICSON, quando fuit vicecomes, habuit hariatam unius iſtorum 20 ſolidos.” Grentebrege was ranked as an hundred. *Vide ſupra.* Lagmen are mentioned in Warwick having fac. et ſoc. See alſo LINCOLN, &c.

† “ In hoc manerio (Biſelie) una hida. Et in dominio ſunt 2 caruc.; et 4 villani, et 8 bordarii, et præpoſitus et bidellus. Inter omnes habent 4 carucatæ. Ibi 8, inter ſervos et ancillas, et vaccar. et daiar. Ibi foreſtarius tenet. dimid. virg. terræ.” P. 180. 2. “ WILLIELMUS comes miſit, extra ſuos manerios, 2 foreſtarios, propter ſilvas cuſtodienſas, unum de Hanlie, unum de Biſelie,” (2 royal manors). There is often mention made of the vaffals belonging to manors. *Vide Arkenfelde* in Herefordſhire. The government of manors is to be found in all inſtitutions of the law of England. The comes had ſuperintended, in ancient times, thoſe of the king. In the ſurvey of Herefordſhire, “ Comes poſuit foris de hoc manerio unam virgatam, et dedit cuidam burgenſi de Hereford. Anſchetel tenet 40 acras, inter planam terram et pratam quas præpoſitus regis EDWARDI præſtavit ſuo parenti.”

they were distinguished, performed the functions of magistrates over it, while the tenants or vassals of the manor composed the judges of the manor court, or hallmote, whose sentences these magistrates carried into execution.

3dly, THE ranks and privileges of the inhabitants appear to have been the same in town and country. Besides, lagmen, as already noticed, we find mention made of thanes in general, as residing in towns, and performing the same duties with those of the country *. Next to the thanes, burgesses are enumerated, and these appear to have been in very different situations. Some of them are described as possessing lands and houses in full property with jurisdiction, and subject to no rent or census to any person; others of them as proprietors of manses simply, and still enjoying jurisdiction, even within this small property †; and others, without this advantage, being subjected to the jurisdiction of particular persons, and yielding to them, or to others, a census or a consuetudo. In fine, others are mentioned, whose manses belonged in property to individuals, to whom they yielded rent and services ‡: And, in some cases, these different situations appear to be more or less blended together ||. Besides these

* SEE note, p. 160.; and the evidence abounds in Doomsday, and elsewhere. WILLIAM of Malmſbury speaks of country barons admitted, long before his time, into the community of London. *Hist. Novor. lib. 11. § 10. f. 106.*

† IN Warwick, it is said, there were 19 burgenſes, “ qui habent 19 maſuras, cum ſa-
“ ca et ſocha, et omnibus conſuetudinibus, et ita habebant temp. Reg. Ed.” The bur-
genſes of Exon, it is ſaid, “ Habent extra civitatem, 12 carucat. terræ, quæ nullam
“ conſuetud. reddunt, niſi ad ipſam civitatem.” A manſe in France denoted not only
a houſe, but 12 bonnés of land belonging to it. In Doomsday, however, maſura and
domus ſeem to be ſynonymous. In Norwich, ſome burgeſſes enjoyed jurisdiction and
patronage over other burgeſſes.

‡ IN Warwick, the king had, *in dominio*, 113 manſes, and the barones regis 112,
which likewiſe paid geld to the king, and were appendages of their eſtates that lay *ex-
tra burgum*.

|| IN Hereforde, “ HERALDUS comes habeb. 27 burgenſes, eaſd. conſuet. hab. quas
“ alii burgenſes.” The præpoſitus, however, “ Habeb. in ſuo cenſu ſupra dictas om-
“ nes conſuetudines. Rex vero habebat in ſuo dominio tres forisfacturas. Hoc erat
“ pacem

these burgesſes, notice is taken of bordarii foccomanni, &c. as aſſiſting the burgesſes to pay the customs or rents due by them *. The burgesſes indifcriminately are every where mentioned as yielding military ſervice, and ſubject to the burdens attending it, according to a certain modus, eſtabliſhed, as it ſhould ſeem, by cuſtom chiefly †. And citizens likewiſe partook of the ſports and amuſements of the nobleſſe of the country ‡.

IN the country, the ſame ſtate of perſons appears. We do not, indeed, find the term *burgesſes* applied to them. But there are numbers of people mentioned among the inhabitants of the country, that ſeem to differ in no reſpect from burgesſes, except in wanting that name, which, it is evident, the nature of their place of reſidence could not admit of giving them. Thus, we

y 2

find

“ pacem ſuam infractam, heinfaram et foreſtellum. Quicumque horum unum feciſſet, emendab. 100 ſol. regi, cujuſcunque homo fuiſſet.” Every maſura, likewiſe, was obliged to ſend a man to attend when the king hunted. In deſcribing the royal manor of Suchlie, it is ſaid, “ In Wireceſtre unus burgenſis, ſed nil reddit.”

* IN Huntedone, it is ſaid, “ T. R. E. fuerunt et ſunt modo 116 burgenſes, conſuetud. omnes et geld. regis reddentes; et ſub eis ſunt 100 bordarii, qui adjuvant eos ad perſolutionem geldi. De his burgenſibus habuit ſanctus Benedictus de RAMSEY, 10 cum ſac. et foc. et omni conſuet.” *Borde* or *borderie* is an old French word, ſignifying a “ domain aux champs, deſtiné pour le menage, labourage, et culture.” Hence *bordelage* in the French law. ARGOU. lib. 2. cap. 4.

† OF the burgesſes of Hereforde, it is ſaid, “ Qui equum habebat ter in anno, pergebat cum vicecomite ad placita, et ad hundrez. ad Urmelavia.” Again, “ Burgenſis cum caballo ſerviens cum moriebatur, habeb. rex equum et arma ejus. De eo qui non habeb. equum, ſi moreretur, habeb. rex aut 10 ſolid. aut terram ejus cum domibus. — Si vicecomes iret in Wales cum exercitu, ibant hi homines cum eo. Quod ſi ire juſſus, non iret, emendab. regi 40 ſolid.” Exon tantum geldab. quando London, York, et Winton, geldab. “ et hoc erat dimid. mark. argenti AD OPUS MILITARE. Quando expeditio ibat per terram, ſerviebat hæc CIVITAS QUANTUM 5 HIDÆ TERRÆ.” Warwick ſent a contingent of 10 burgesſes to aſſiſt in a war at land, and 4 boatſwains, or 4 lib. of pence in a war at ſea. “ Qui monitus, non ibat,” paid 100 ſolidi. Wilton ſent a man for every five hides, Ledceſtre ſent 12 as a contingent, &c.

‡ “ Et cives Londoniæ habeant fugationes ſuas ad fugandum, ſicut melius et plenius habuerunt antecellores eorum ſcilicet in Chiltre, et Middleſexe, et Surreie.” *Charter by Inſpeximus of HEN. I. and HEN. II. and RICH. I.*

find there people possessing single manſes, or ſingle roods or half roods of land, and ſometimes larger quantities, as ploughgates, and yielding military ſervice, and various cuſtoms, to the king or individuals. The rights of the owners of theſe lands likewiſe appear to have differed in the ſame way as thoſe of burgeſſes, and to have been ſubjected to a ſimilar diverſity of burdens *. I need not add, that we find the whole country abounding with foccomanni, bordarii, porcarii, bovarii, who appear to have been in ſome degree of ſervile condition, and diſtinguiſhed from each other chiefly by names derived from the particular ſpecies of rent or ſervice yielded by them, or other ſuch little circumſtances.

THE above particulars, and the authorities on which they are ſtated, appear to me, when maturely conſidered, to leave no reaſonable doubt, that the towns enjoyed no peculiar ſyſtem of adminiſtration, but were diſtinguiſhed merely as places of ſome ſtrength, where authority was better enforced, and where the ſmaller proprietors, and perſons of ſervile condition, who had preſerved or obtained a degree of liberty, reſorted in numbers, for the ſake of mutual protection. If the town belonged to an individual, it was governed in the ſame manner as the reſt of his eſtate. If the town belonged to different people, it formed, along with what was afterwards called its *liberty* (*i. e.* the *banlieue* or territory adjoining and belonging to it), a diviſion of the country, or a political community, and was ranked and governed accordingly.

AUTHORS ſeem, in general, to have ſteered very wide of this ſimple and natural concluſion. Some, ſtruck with the oppreſſive reſtraints

* In the ſurvey of a manor, it is ſaid, “ ANSGOT, homo comitis, tenet dimid. virg. terræ. Et ULVIET unam hidam liberæ terræ.” P. 180. In the manor of Arkenfelde, the king had 96 men, who, with their men, held 76 caruc. “ et dant de conſuetud. 4 ſextar. mellis, 20 ſol. pro ovibus, quas ſoleb. dare, et 10 ſol. pro ſumagio; nec dant geld. aut aliam conſuet. niſi quod pugnant in exercitu regis, ſi juſſum eis fuerit.” If a villein died in this manor, the king had an ox; if a freeman, his horſe and arms. But a page of Doomsday cannot be peruſed without perceiving abundant evidence of the aſſertion in the text.

restraints and burdens to which the more ancient charters of incorporation, as well as Doomſday, prove that the inhabitants of towns were ſubjected, have inferred, that they were no better than flaves, and never could have had ſufficient conſequence to reſort to the diet. Other authors, again, have maintained, that the miſerable ſituation of towns aroſe only in the corruption of the feudal ſyſtem, and that charters conferred on them no more than a reſtoration of their ancient liberties. Both appear to have been partly miſtaken in theſe opinions, and partly in the right.

THE *nobleſſe citadins* certainly once abounded in the greater towns, both in Britain and on the continent. And it was natural it ſhould be ſo, as long as towns were places of defence, and not manufacturing communities. In Germany, we have frequent mention of city nobles, under the name of patricians, or of *hauffegenoffen* and *muntzer* (*confreres* and *monnoyers*), from being united into a ſociety, to which the care of the coinage or mint was committed. In that country, it is well known that this order flouriſhed long before the twelfth century, when HENRY V. emancipated the fervile artiſans, and LOTHAIRE II. granted charters of incorporation; that it long afterwards preſerved ſcrupuloſly a ſeparation of blood from the ſimple free burgeſſes, endeavouring, as formerly, to monopolize the offices of lagmen, echevins or jurats; and that, from a remote antiquity till about the times of CONRAD IV. it maintained its rank, and yielded military ſervice on the ſame footing with the nobles of the country, from whom there is evidence that many belonging to it were deſcended *. In Italy, again, it cannot be diſputed, that, long before the reign of HENRY V. the cities were bodies politic, of much conſequence: And the ariſtocracy which anciently prevailed in all of them, as well as in Germany, of which Switzerland

* In 928, the emperor HENRY I. cauſed a ninth part of the country nobleſſe to reſide in the towns on the eaſtern frontier of Germany, in order to guard it againſt the Slavonic nations.

Switzerland was a part, proves, that they contained, in remote times, persons of family, and men better acquainted with arms than industry. In Spain, also, as far back as the *fueros* of the towns, the principal inhabitants of them were cavalieros and escuderos, and yielded military service like the nobility of the country *. In the same way, in France, we find, during the first and second Race, the towns of a warlike character having counts, *scabini*, &c. at their head †: And the Franks, who conquered Palestine in the early times of the third Race, assumed arrangements which prove, that a city noblesse was sufficiently agreeable to their domestic customs ‡. It is certainly in the same way alone, that we can explain how, in Britain, the citizens

* MANY of the principal Spanish towns long preserved independence of the Goths; and it appears from a law of CHINDASINTHUS, who reigned about A. D. 650, that, notwithstanding the submission of the towns, on the renunciation of Arianism, the distinction between the *curiales* and *plebeians* of the Roman *municipia* remained in force: *L. L. Visig. lib. 5. tit. 4. cap. 19.* The same law likewise proves, that the jurisdiction of the *comes* obtained in the Spanish towns, as well as in the country districts; and Dr ROBERTSON, in his History of CHARLES V. v. I. p. 345, &c. shows, That the towns made a distinguished figure, as far back as there are any accounts of the kingdoms which arose on the ruins of the Arabian powers. It is certain, that the principal inhabitants of towns enjoyed the honours of the country noblesse; and this will hardly appear extraordinary, when it is considered, that, during the long warfare with the Moors, towns were the natural bulwarks to which the inhabitants of the country must have resorted in times of danger.

† GREGORY of TOURS, lib. 4. § 30.; lib. 6. § 11. verb. *seniores civium*; and lib. 8. § 18. 21. 45.; lib. 10. § 5. And many other authors might also be quoted to the same effect.

‡ THE principal inhabitants of Jerusalem, Napoli, Acre, and Sur, furnished 666 knights, and the simple burghesses furnished, together with the churches, 5075 sergens to the army; and these knights seem to have been, in no respect, inferior to those furnished by the country barons. *Affises de Jerusalem, cap. 326. &c.* In the time of St LEWIS, Paris contributed to the war of Flanders 400 cavalry and 200 infantry. The fine for absence was 60 *solidi*. Fines of this nature were levied on burghesses in very ancient times. Every person, without distinction, having 4 *manfes* in property, or benefice, was obliged to attend in war. BALUZ. tom. I. p. 489. And we have burghesses particularly mentioned as subject to this duty. *Edict of CHARLES LE GROS, ad ann. 880.*

zens of certain of the principal towns, as London and the Cinque Ports, were named barons or thanes, and mentioned as resorting in an aggregate body to the national diet, and there possessing much influence*.

Again, though we sometimes find inhabitants of towns destitute of the right of alienating their property; that the crown was their heir instead of their children; and that services of all sorts, or compositions in lieu of services, were exacted from them in the most oppressive manner; it neither follows, that all the inhabitants of towns were in this situation, nor that the inhabitants of the country were in happier circumstances. Various causes tended to create a multiplicity of restraints and services. The German kings subsisted chiefly by gifts from the freemen of the nation, and, like the heads of all pastoral tribes, received from them lodging, forage, and attendance when they journeyed. After the conquest of the Roman provinces, these voluntary aids degenerated into a variety of customary taxes, uncertain services, and oppressive compositions. Fines also were prescribed for all manner of delinquencies, and seem to have been employed as an inducement to the execution of the law, by rendering every proprietor a profiter from it. Personal protection, likewise, was not only to be paid for by a yearly rent to the king, or potent individual who afforded it, but became the condition of various restraints as to marriage, alienation, succession, &c. over those who received it. Besides, the imperfections of agriculture, and the disorders arising from the weakness of government, often reduced even freemen to the greatest hardships; and it was lawful for them to sell themselves into slavery; and it was also lawful to purchase emancipation or relief, by submitting to various burdens affecting their posterity, as well as themselves. In fine, the jealousy and

* ON the death of CANUT, the Saxon Chronicle relates, that HAROLD was chosen king by Earl LEOFRIC, and the mariners of London, and almost all the thanes north of the Thames. "Major Londoniæ, et alii barones Londoniæ attornaverunt," &c. 6. HEN. III. Rot. 5. BROMPTON, and the Norman writers use *baro* to denote thane; and the records for several reigns after the conquest employ both terms promiscuously. MADOX. *Hist. Exch.* BOULAINVILLIERS *Etat de la France*, v. 3. p. 56.

and exclusive spirit natural to rude communities, and the powers of proprietors to make particular regulations, and establish tolls, and other customs, within their estates, produced restraints, from which again the crown sold exemptions. Now, all these sources of personal restraints reached equally to the country and to the towns, and appear accordingly from Doomsday, not to mention other evidence, to have overwhelmed both*. The towns, indeed, were early in condition to obtain freedom from them by actual purchase and by special grants; and, accordingly, their former state under them has drawn more attention; while the country, obliged to wait for the gradual influence of political advancement, has derived its freedom slowly and insensibly, so that its ancient oppressions have attracted less observation.

NOR is there any reason for supposing, that towns were, in remote times, possessed of those liberties, and of that constitution, which was conferred on them by the charters of incorporation. Even among the Romans, manufactures were not carried on in great towns. The manners of their conquerors were certainly little fitted to make any innovation in this respect;

* I HAVE abundance of evidence to offer of the particulars in the text. It, however, is voluminous; and *they*, in general, are well known. I shall, therefore, quote only two very curious passages from Doomsday: "Northamptonshire redd. firmam trium noctium, 30 lib. ad pondus. ad canes 42 lib. alb. de 20 in ora. De dono reginæ et de feno, 10 lib. 5 oras. De Accipitre, 5 lib. De Summario, 20 fol. De Elemos, 20 fol. De eq. venator, 20 fol." See also Ledecestre and Warwick, &c. In describing the customs of Arkenfelde in Herefordshire, it is said; "Si quis Wallensium occid. hominem regis, et facit heinfaram, dat regi 20 fol. de solut. hominis, et de forisfac. 100 fol. Si alicujus Taini hom. occiderit, dat 10 fol. domino hominis mortui. Quod si Wallensis Wallensem occiderit, congregantur parentes occisi, et prædantur eum qui occidit, ejusque propinquos, et comburunt domos eorum, donec in crastinum circa meridiem corpus mortui sepeliatur. De hac præda, habet rex terciam partem. Illi vero totum aliud habent quietum. Si vicecomes eos evocat ad Sciremot. meliores ex eis 6 aut 7, vadunt cum eo. Qui vocatus non vadit, dat 2 fol. aut unum bovem regi. Qui de hundred. remanet, tantumdem persolvit. Similiter emendat qui, jussus a vicecomite secum ire in Wales, non pergit. Nam si vicecomes non vadit, nemo eorum ibit. Cum exercitus in hostem pergit, ipsi faciunt avantwarde in reversione rerewarde. Hæ consuetud. erant Wallensium." *T. R. E. in Arkenfelde.*

spect ; and it accordingly appears from the domestic regulations of CHARLEMAGNE, that the manufactures, consumed by the royal household, were still prepared in the ancient manner, in his fisco or domains. It is, therefore, extremely improbable, that any merchants, or artisans, that may have belonged to great towns, in the middle ages, were persons of consequence ; and it is equally improbable, that, if they had been so, and been possessed of property and arms, and been formed into corporate bodies, they should have become the slaves or dependants of a few owners of land in their neighbourhood. But, if the ancient towns were nothing else than fortified *pagi*, to which the great proprietors around them resorted * ; and, if the rest of the inhabitants consisted either of clients, or dependants of these proprietors, subsisting by cultivating little portions of land, and fighting under their banners, or of persons of servile condition, who had obtained, or who sought for some degree of liberty, and earned their living by exercising crafts, or assisting the burghesses in their duties ; the whole history of towns becomes perfectly natural, and the origin of that situation which led to incorporations is explained.

BEFORE incorporations were erected, there must have been societies, resulting from voluntary confederations, which found it desirable to obtain the sanction of law to their union. But it is in times of trouble and oppression that people have recourse to private associations, and to the patronage of individuals, for that support and protection which government is unable to afford them ; and government, sensible of its debility, willingly gives its countenance to any measures that have the appearance of

* LONG before charters of incorporation, WILLIAM the Conqueror considered them in this light : “ Nullum mercatum vel forum sit, nec fieri permittatur, nisi in civitatibus, et in burgis et muro vallatis, et in castellis, et in locis tutissimis, ubi consuetudines regni nostri — deperiri non possunt, nec defraudari nec violari. — Et ideo castella, et burgi, et civitates sitæ sunt, et fundatæ, et ædificatæ, scilicet ad tuitionem gentium et populorum regni, et ad defensionem regni, et idcirco observari debent, cum omni libertate et integritate et ratione.” *L. L. GUL. I. c. 61.* Saxon history justifies the assertion ; and the laws of ATHELSTAN, c. 12. and 13. furnish the regulation. The *burghbotam*, or expence of repairing the fortifications of towns, affected accordingly every land-estate in the kingdom.

of promoting a degree of public order, or affording shelter against private wrongs. We find accordingly, in the Saxon times, voluntary associations entered into by men of different ranks, with a view to afford security to each other, and government approving of the regulations to which they had subjected themselves *. National industry, however, was not then so far advanced as to permit us to suppose, that mere artisans were of sufficient consequence to establish such societies. The only embryo that can be discovered of a fraternity for a commercial purpose, is the gilda, which belonged to certain towns, and appears to have been an institution somewhat resembling the German muntzer †, and possibly, like those fraternities, to have had some charge of the coinage, and of receiving the king's revenue in good money ‡.

IN all probability, however, this institution suggested to the rest of the inhabitants the idea of forming similar associations. We know, that, in Germany, the simple burgeses associated in this way, and, becoming wealthy and considerable, obtained a share of the privileges of the muntzer; and the bordarii and cottagers, who originally inhabited only the suburbs of towns, (*extra murum*),

* IN Canterbury, "Burgenses habeb. de rege 33 acras prati in gildam suam."

† THE mint of a district was, no doubt, originally under the care of the magistrate. The following grant of the year 955 shows that this was the case, and that towns in Germany were very similar to what they were in England at the time of the survey: "Concedentes, &c. omnem burgum, et universa quæ ibidem ad dominationem et potestatem comitis pridem pertinuisse visa sunt; forum scilicet, teloneum, monetam, et omnem districtum, cum terra et mansionibus ipsius burgi." BOUQUET, tit. 9. p. 618.

‡ THE burgh of Huntedun, which was ranked as the fourth part of a hundred, "pro 50 hidis defendeb. se ad geld. reg. Sed modo non geldab. in illo hund. postquam Rex Ws. gildum monete posuit in burgo." The monetarii appear to have paid double the heriot, or relief, and sometimes quadruple the custom of the simple burgeses. It was probably the lucrative nature of the business that made it an object for the city noblesse in Germany to take charge of it. The monetarii in England had "saccam et socham suam." L L. ATHELSTANI, c. 14. provide, That every burgh was to have at least one; and when exemptions from the county jurisdictions were bestowed on incorporations, there is very commonly a reservation as to the monetarii: "Exceptis monetariis et ministris nostris." Charter of JOHN to London. In Scotland, at this day, the guild brethren, as they are called, are distinguished as superior to the handicraftsmen, or trades.

rum), and came there to be called *cives opifices*, or *artisans*, soon followed the example of the *francs bourgeois*, and, forming opulent fraternities, compelled them, in their turn, to allow of a participation of the municipal government. It was from this revolution that the German towns became distinguished by industry and wealth; for the muntzer found it necessary to have recourse to commerce, and to join the free burghesses in trading adventures, if they did not chuse to be eclipsed, in point of fortune, by their inferiors.

THERE is every reason to conclude, that similar events in Spain, France, Britain, and other countries, were produced from similar causes. The turbulence of the middle ages every where enabled the more wealthy, or the more fortunate, to reduce their neighbours under different degrees of subjection. Towns afforded an opportunity to the better sort to form, for mutual security, leagues or societies, which counteracted the progress of this calamity. Princes countenanced these associations, and such as were formed by the inferior inhabitants in imitation of them; and these bodies again, either by purchase, by force, or by growing customs, established municipal governments, that maintained exemptions from the ancient system of subordination, which was naturally detested by the industrious as burdensome, tumultuary, and unsuitable to their habits. The towns accordingly ceased to resort to the diets. Their warlike gentry, the companions of the sovereign, either left them, or mingled in those societies of commerce or manufacture which governed them. Becoming, therefore, assemblages of manufacturers, rather than national bulwarks, they necessarily appeared degraded in the eyes of an age which was the source of chivalry and the offspring of the feus.

BUT that security which municipal governments afforded, soon rendered the towns wealthy and formidable. Kings, then, applied to them for aid, and offered them privileges and beneficial laws in return. Hence the towns came to negotiate by means

of delegates with their sovereigns, and with each other; and, from little detached dependent plebeian republics, came to form a body which resorted to the diets, as a third and an ignoble estate, formerly unknown in the European constitutions.

THESE observations, it is hoped, are sufficient to justify the position, That the same simple arrangements of government pervaded the whole of a German nation, at its establishment in a Roman province; and that it was only in consequence of a revolution, the steps of which may, in general, be distinguished, that we are entitled to suppose that the idea of assembling a nation by its representatives was suggested or realized*.

* It is scarce necessary to remark, that the claims of one or two English boroughs for the privilege of electing members of parliament, on the ground that they had resorted to the Saxon diets, is rather explained by, than repugnant to the above hypothesis. The evidence that was offered of the grounds of claim has not been preserved; and the age in which it was offered is distinguished by having been imposed upon by the grossest forgeries. The tradition, however, of anciently resorting to the diets in the manner I have stated, may naturally, both have suggested the claim, and rendered it successful.

VIII. *An ESSAY upon the PRINCIPLES of HISTORICAL COMPOSITION; with an Application of those Principles to the Writings of TACITUS.* By JOHN HILL, M. A. F. R. S. EDIN. and Professor of Humanity in the University of EDINBURGH.

P A R T II*.

[Read by the Author, Feb. 21. 1785.]

THE proofs of sound judgment in the writings of TACITUS are extremely numerous. From the choice of his subjects, he appears to have been perfectly acquainted with the nature and the extent of his own powers. Though he was considerably advanced in life before he began to write history, yet the closeness of his application enabled him to unfold that wisdom which his experience had furnished. In spite of an ardent love of fame, he avoided the rock upon which most authors split, and wisely forbore to solicit the attention of the public, till he could for certain command its respect.

WHILE he was governor of Belgium, he did not waste his time in idleness, nor in devising plans for the increase of his fortune. The generosity of his spirit made him abhor that cruelty with which other Prefects oppressed their subjects. When the concerns of his government did not engage his attention, he viewed the rude manners of the Germans with an attentive eye; and the acuteness of the observer was happily suited to the nicety of the subject. The discussions of the philosopher were, with him, a relaxation from the cares of the statesman.

* See PART I. p. 76. of PAPERS of the LITERARY CLASS.

statesman. During his abode in Belgium, he collected materials relating to the first stage of human society, which form the most valuable treatise that is even yet to be found upon the subject.

HE next wrote the life of his father-in-law AGRICOLA. In this treatise, we have reason to admire the qualities of an affectionate heart as much as the accomplishments of an able writer. As a piece of biographical writing, it may be deemed a standard. Nothing needful to be known is suppressed, and nothing superfluous is admitted. AGRICOLA is made so completely respectable as a soldier, and amiable as a man, that the character drawn may seem perhaps too near to perfection. It does not appear, however, that the contemporaries of TACITUS ever accused him of partiality.

AFTER the life of AGRICOLA, he composed his history, which begins at the death of NERO, and ends with the reign of TITUS. It is unfortunately so much mutilated, that it comprehends little more than a twentieth part of its subject. That our author knew precisely the nature of the period he had chosen, is evident from his own words: "Opus aggredior (says he) "opimum casibus, atrox præliis, discors seditionibus, ipsa etiam "pace sævum*." Throughout the work, a most exact unity is preserved, in the midst of a multiplicity of facts. The views of VESPASIAN in the east are suggested before the dispute between OTHO and VITELLIUS had come to a conclusion, and the reader is thus prepared for contemplating a new struggle. The disturbances in Germany and in Britain solicit his attention when they occur; but so as not to break in upon the main story. Foreign and domestic occurrences find a place suited to their respective importance; and the account of the war in Germany, and that of the expedition of TITUS in Judea are kept completely distinct, and made clearly intelligible.

IN

* Hist. lib. i. cap. 2.

IN the annals of TACITUS, which were the last of his works, though their subject be prior to that of his history, a more distinct arrangement is to be found than could well be expected from their title. From the author's ability, the narration in them is better conducted than that in easier subjects is by the generality of those who have wisely adopted them. He was, at the same time, thoroughly aware of the difficulties he encountered. He insinuates, that the period chosen presents a multiplicity of facts too inconsiderable to be the foundation of a legitimate history; and that those great events no longer existed, which as often hide the historian's defects, as they receive embellishment from the force of his talents. "Nobis in
" arcto, et inglorius labor. Immota quippe aut modice laceffita
" pax, mœstæ urbis res, et princeps proferendi imperii incurio-
" fus erat. Non tamen sine usu fuerit, introspicere illa primo
" aspectu levia, ex quîs magnarum sæpe rerum motus oriun-
" tur *."

As an impartial historian, TACITUS is, without doubt, entitled to high praise. He arraigns the conduct of the underserving, without regard to their rank; and appears to have been, in every case, devoid of prejudice. At the beginning of his history, he lays down a rule for other writers, to which he gives reason to think that he himself will rigidly adhere. "Mihi GALBA, OTHO, VITELLIUS, nec beneficio nec injuria
" cogniti. Dignitatem nostram a VESPASIANO inchoatam, a
" TITO auctam, a DOMITIANO longius provectam non abnu-
" erim; sed incorruptam fidem professis, neque amore quif-
" quam, et sine odio dicendus est †." A beautiful struggle is here exhibited between the emotions of his gratitude and his sense of what was right; but he holds it dishonourable even to be grateful at the expence of truth.

THAT the views of TACITUS upon human affairs are profound and just, must be obvious to every person who has judg-
ment

* Ann. lib. 4. cap. 32.

† Hist. lib. 1. cap. 1.

ment to follow him. The perusal of his works requires more than an ordinary exercise of attention. They are fitted to instruct rather than to amuse. Their choicest beauties lie hid from vulgar observation; and the longer they are contemplated, even by the discerning, the higher is the pleasure they afford. If ever any historian understood the springs of human action thoroughly, it was TACITUS. His penetrating eye never rested upon the surface of objects, but searched their inmost recesses. His mind seems to have been formed for catching those peculiarities in character, which, though not easily discerned, have no small effect upon the conduct of men. Of this we have an instance in the case of CÆSONIUS PÆTUS, who had been improperly appointed by NERO for the defence of ARMENIA, and who rejected the advice of his experienced counsellors. “*Verum ubi a viris militaribus adversus urgentes casus firmatus erat, rursus ne alienæ sententiæ indigens videretur, in diversa ac deteriora transibat* *.” An ordinary writer would have either told the fact simply, or have mistaken its cause; but it became the subtilty of TACITUS to expose the false pride which made PÆTUS reject the counsel which he needed, and add obstinacy to ignorance.

THE observations of TACITUS sometimes illustrate not only the characters of the persons to whom they are applied, but the nature of the times in which they lived. He is, indeed, as sparing of his expression as he is profuse of his matter. This appears upon many occasions; and particularly in the account given why POPPÆUS SABINUS had been raised from a very ordinary station to offices of trust and distinction. “*Fine anni POPPÆUS SABINUS concessit vita, modicus originis, principum amicitia consulatum ac triumphale decus adeptus: Maximisque provinciis per quatuor et viginti annos impositus; nullam ob eximiam artem, sed quod par negotiis, neque supra erat* †.” The elevation of this SABINUS (it should seem)

* Ann. lib. 15. cap. 10.

† Ibid. lib. 6. cap. 39.

seem) was owing, not to the precise extent of his abilities alone, but to the sentiments which his jealous superiors entertained of them. From the measure of talents which he possessed, they perceived, that the business of the public would not be neglected; and, from the mediocrity of those talents, that its tranquillity would not be disturbed.

OUR author's observation upon the fall of SALLUSTIUS CRISPUS is also worthy of himself. When this person was advanced in life, he lost the favour of TIBERIUS, which he had long enjoyed; and TACITUS hazards a conjecture as to the fate of courtiers in general. The mutability of their situation is often ascribed to the caprice of their patrons alone; but our author, with much ingenuity, and perhaps equal justice, ascribes this to a capricious levity both in the patrons and in the objects of their beneficence. "*Ætate provecta speciem magis in amicitia principis quam vim retinuit. Idque MÆCENATI acciderat, fato potentiae raro sempiternæ: An satias capit, aut illos cum omnia tribuerunt; aut hos, cum jam nihil reliquum est quod cupiant **."

BUT almost the whole account of the reign of TIBERIUS contains the exposition of a character not more odious than it was singular. An ordinary writer might have marked some of its general features, but such a writer as TACITUS alone could unfold its intricacies. In almost every action, and every speech, the tyrant had something to conceal. Under the veil of moderation, he was ever anxious to undermine the liberties of his people. Flattery, however artfully administered, was, from the suspiciousness of his nature, apt to give him offence; and, though he was provoked with the servility of his subjects, yet he would not permit them to be free. This struggle between contending humours, together with its effects upon those around him, is beautifully insinuated in the following words. "*Acerbeque increpuit eos, qui divinas occupationes, ipsumque do-*

a a

" minum

* Ann. lib. 3. cap. 30.

"minum dixerant. Unde angusta et lubrica oratio sub principe, qui libertatem metuebat, adulationem oderat*."

IN unfolding the character of SEJANUS, who was long the favourite, and even the director of TIBERIUS, no less art is displayed than in unfolding that of the emperor himself. Along with many bad qualities, this SEJANUS had possessed the most wonderful address. While the other subjects of TIBERIUS dreaded the violence and the caprice of his humours, he had art enough to render both the instruments of his elevation. He could make even the tyrant conceal his lusts, through a fear, or an attachment, of which he was the object. "Obtectis libidinibus, dum SEJANUM dilexit, timuitve †." By an unfortunate chasm in the writings of TACITUS, the history of the fall, and the full exposition of the character of SEJANUS are now lost. His daring ambition, and almost unfathomable subtilty, present a subject that suits the hand of an able artist; and some of the great outlines still remaining shew clearly the value of the picture when complete.

BUT, although TACITUS draws his characters in strong colours, yet there is nothing in them bordering upon extravagance. The singularity of their conduct justifies that of the view held forth. Though many foul passions deformed the character of TIBERIUS; yet our author is candid enough to point out in it the smallest symptom of virtue. He repeatedly frees him from the imputation of avarice. He even seems happy in extolling the merit of his reply to ADGANDESTRIUS, who offered to destroy ARMINIUS, if the senate would send him poison for the purpose. "Responsum esse, non fraude neque occultis, sed palam et armatum populum Romanum hostes suos ulcisci. Qua gloria æquabat se TIBERIUS priscis imperatoribus, qui venenum in PYRRHUM regem vetuerant, prodiderantque ‡."

As the character of TIBERIUS is not held forth as completely abandoned, so neither is that of GERMANICUS held forth as completely

* Ann. lib. 2. cap. 87.

† Ibid. lib. 6. cap. 51.

‡ Ibid. lib. 2. cap. 88.

completely virtuous. TACITUS shows that partiality to virtue which becomes its friend ; but his judgment was too strong to be misled, even by a venial bias. In spite of the amiableness of GERMANICUS, in almost every situation, he discovers, upon one occasion, the frailties of a man. At the interview between him and PISO, they met “ Firmato vultu, PISO adversus me-
“ tum, GERMANICUS ne minari crederetur. Postremo paucis
“ familiarium adhibitis sermo coeptus a CÆSARE, qualem ira
“ et dissimulatio gignit *.”

THOUGH the observations of TACITUS be profound, yet he rarely shows any anxiety, or employs any artifice to set them off to advantage. The current of his narration runs often so smooth, that the treasures with which it is impregnated are apt to escape unnoticed. He wrote for those only who had acuteness to catch his hints, and ability to apply them as they deserve. A profound observation often presents itself unexpectedly ; and the reader's admiration is bestowed the more willingly, because the historian's sense of dignity made him averse from courting it. The cause of RUFUS's severity is beautifully painted at the end of the following sentence, by the use of four words. “ Quippe RUFUS diu manipularis, dein centurio, mox
“ castris præfectus, antiquam duramque militiam revocabat,
“ vetus operis ac laboris, et eo immitior quia toleraverat †.”

THE desperate situation of the old emperor GALBA, who was employed in offering a sacrifice, even after the schemes of OTHO his successor had begun to take effect, is also delicately expressed in a few simple words. “ Ignarus interim GALBA et
“ sacris intentus, fatigabat alieni jam imperii deos ‡.”

WITH much judgment, also, and, at the same time, with great simplicity of expression, he assigns the reason why ANICETUS, who had been employed by NERO, first to attempt drowning his mother, and afterwards to slay her, incurred the emperor's displeasure. “ Levi post admissum scelus gratiâ, dein

a a 2

“ graviore

* Ann. lib. 2. cap. 57.

† Ibid. lib. 1. cap. 20.

‡ Hist. lib. 1. cap. 29.

“ graviore odio, quia malorum facinorum ministri quasi ex-
 “ probrantes aspiciuntur *.”

SUCH striking and deep remarks seem to spring spontaneously from the mind of TACITUS. They are, for most part, made without any seeming effort, and without ostentation. Though replete with instruction to the most intelligent reader, yet they often teach without mortifying him, and excite no disgust at the historian's arrogance.

THE judgment of TACITUS is remarkable; not only in those single strokes, by which he unexpectedly, and at once, unfolds something not understood, but also when he warns his reader that he is to do so, and solicits his attention. In his descriptions of character, there is none of that spurious subtilty which balances circumstances not duly opposed. Every antithesis stated has its foundation in nature, and bespeaks that solid acuteness which is above affectation. Of this, the character drawn of GALBA, in the 49th chapter of the 1st book of the History, furnishes one out of many instances. “ Hunc exitum habuit
 “ SERGIUS GALBA tribus et septuaginta annis, quinque prin-
 “ cipes prospera fortuna emensus, et alieno imperio felicior,
 “ quam suo. Vetus in familia nobilitas, magnæ opes: ipsi
 “ medium ingenium, magis extra vitia quam cum virtutibus.
 “ Famæ nec incuriosus, nec venditor. Pecuniæ alienæ non
 “ appetens, suæ parcus, publicæ avarus. Amicorum liberto-
 “ rumque, ubi in bonos incidisset, sine reprehensione patiens:
 “ si mali forent, usque ad culpam ignarus. Sed claritas nata-
 “ lium, et metus temporum fuit obtentui, ut quod segnitia
 “ erat, sapientia vocaretur. Dum vigeat ætas, militari laude
 “ apud Germanias floruit. Proconsul Africam moderate: jam
 “ senior, citeriorem Hispaniam pari iussit a continuit: major
 “ privato visus, dum privatus fuit, et omnium consensu capax
 “ imperii, nisi imperasset.”

FROM

* Ann. lib. 14. cap. 62.

FROM all the observations made, and all the passages quoted, we may infer, that TACITUS was eminently endowed with that judgment, which, besides giving the feeling and the fancy of the historian their due value, is itself the foundation of many capital qualities. This enabled him, we find, to chuse and to arrange his subject, so as to do most justice to his own abilities, and to give most instruction to his reader. It secured the fairness of his decisions, in spite of those personal connections with which most men are blinded. It made him sagacious in his opinions as to past things that are doubtful, and as to future things that are contingent. While it enabled him to see objects as they were, and insured his reader against the impertinence of observations that are either trifling or misplaced, it also repressed the weak vanity, which lessens the merit that it means to exaggerate.

As the power of judgment comes late to maturity, both in the individual and in the state, so history, in its most improved form, is never one of the earliest efforts of national genius. The perfection of the poet's art depends chiefly upon the acuteness of his feeling and the vivacity of his fancy. In the improvement of these powers, little or nothing is left to the possessor's industry, while judgment is fortified by the recollection of past errors, and strengthens slowly by repeated trials. As the improvement of national wisdom, too, is the fruit of national experience; so history cannot flourish but where interesting facts present themselves, and where their value is distinctly seen. Though those powers which serve to embellish truth must not be extinguished in the historian, yet judgment must prescribe the laws by which they are to be controlled. Between the emotions of mind, and the respective impulse that is the cause of each, a steady proportion is thus preserved. As too much brilliancy in any object prevents it from being distinctly seen; so the brightness of the reader's fancy must illuminate

minate the subject of narration, without dazzling the reader's eye.

THE position now advanced, as to the period in society at which historical narration appears in its most improved form, will be found to be justified by facts. In every literary æra, the poet has been the first to offer the fruits of his genius, and to court the disposers of that approbation which is the reward of his excellence. Before even the remotest period to which any human record reaches, HOMER had displayed the wonderful powers of the Greek language; and, by his own practice, had fixed those principles upon which future artists were to perform, and future critics to judge. At Rome, the poems, not only of LIVIUS ANDRONICUS, ACCIUS, and PACUVIUS, but of PLAUTUS and TERENCE, had attracted the notice of their countrymen, before any tolerable prose composition appeared. Upon the revival of letters, when those arts were cherished at Florence, which the Turks had banished from Greece, the history of literature presents the same appearances. The Genius of Italy, after slumbering for ages, was first awakened by DANTE and PETRARCH. In France, a taste for the beauties of prose was ushered in by the poems of MALHERBE. In Britain, too, that elegance which has distinguished the compositions of some of our countrymen, was first discernible in the works of our poets. The assertion, then, as to the period of historical genius, seems justified by facts. In every region in which literature has as yet flourished, capital productions in history have announced the maturity, though they could not secure the continuance of classical taste. Like a bird of passage, impatient of the rigours of every climate, this is ever ready to change its abode.

THOSE passages, produced now and formerly from TACITUS, though fraught with beauties of the first order, enable us to form but an imperfect judgment of his merits. We are, indeed, fairly entitled to infer, that the genius which gave existence

istence to those beauties is no ordinary one ; but, before we decide as to its precise extent, we must mark the instances in which that genius has failed, as well as those in which it has been successful. The prospect upon which we have hitherto dwelt, though rich, is, in some degree, delusive. An eulogy that acknowledges no fault can also confer no praise ; and that approbation only is to be valued which rests on the balance of beauties that have been opposed to defects.

THE style of TACITUS has been justly condemned as being, in some places, harsh, and not fitted to allure the attention of the reader, by gratifying his taste. This fault is the less pardonable, as it springs from intention, and not from carelessness. From wishing to shun that servile vanity, by which most writers court the admiration of their readers with excessive eagerness, TACITUS has fallen into a contrary extreme.

In vitium ducit culpæ fuga si caret arte.*

He sometimes throws out his deepest reflections with an indifference that is suspicious, so that the absence of parade is not always an indication of his modesty. The abruptness of his manner borders upon a studied sententiousness ; and, from being too conscious of his own depth, he is apt to disgust as being dogmatic and oracular. He writes like a person confident that his opinions are sound, regardless of those of his reader, and unwilling to wait till the capacity of ordinary men permits them to follow him.

FROM the abruptness of the style of TACITUS, some critics of respectable authority have asserted, that he had made SALLUST his pattern. With all deference for their opinion in other cases, we must in this differ from them. If the originality of the genius of TACITUS has permitted him to copy any writer, it is THUCYDIDES. In the use of certain words and forms of construction, he may have copied SALLUST ; but few historians are more nearly opposite in their manner. In the style of SALLUST, there is a studied elegance, at which his supposed imi-

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* HOR. de Arte Poet. v. 31.

tator never aimed; and, in the sentiment of TACITUS, there is a depth which SALLUST could never rival.

TACITUS is accused of being vain of his erudition, and of seizing even the slightest opportunities of displaying it. He is said to be at too much pains to give the origin of customs, both foreign and domestic, and to make too frequent references to the more remote events in the history of his country. This accusation I hold to be groundless. A philosophic mind, like that of TACITUS, must have seen a value in certain facts that escapes common observers. His benevolence, too, may have urged him to stimulate the remaining virtue of his contemporaries, by recalling to their remembrance the merits of their ancestors. As the empire declined, he perceived, that the materials of history were the more likely to perish; and, happily for society, he possessed both that precision, by which the antiquary establishes single facts, and that power of arrangement, by which the historian states a number in that order which is to form his detail.

THE energy of the style of TACITUS has been condemned as romantic. This may appear to be the case to those who never felt that enthusiasm which warmed his breast. The glowing language of an elevated mind tallies ill with the cold propriety of vulgar criticism. The learned Bishop of Worcester, in his notes upon HORACE's art of poetry, tells us, that figurative expression became the dignity of the historic character and genius of TACITUS; but that, had his contemporary SÆTONIUS used the same language, he would have set his readers a-laughing*.

OUR historian's descriptions have been charged with inconsistency; but this is owing to the inconsistency of those characters that are their subjects. A more superficial observer would have presented a picture less just, though more uniform in its parts; yet the merit of an historian is to be tried by the consonancy of his relation with what existed, not with what
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* Vol. i. p. 75.

may be supposed. The singular duplicity of many of the characters in TACITUS furnishes a full vindication of him in the respect mentioned. His sagacity had escaped his critics, who, by charging him with the want of penetration, have unluckily discovered their own.

BUT the most partial admirers of TACITUS cannot deny, that his writings are sometimes deformed with pieces of conceit and affectation. A certain quaintness and minute elegance in some parts of his works stands opposed to the manly beauties of others. Though this affectation in our author be real and highly culpable, yet it is sometimes complained of when it does not exist. He is accused of excessive refinement in his views, and of assigning motives for conduct, of which even the agents were unconscious. But it may be easier for a weak mind to deceive itself than an observer of such deep penetration. In nice cases, he generally suggests a variety of motives, and leaves it to his reader to select the most probable. Where judgment alone is concerned, no writer, perhaps, was ever less apt to err. As soon as the discernment of his critics fails, their candour fails along with it; and they chuse rather to attribute the obscurity of the author to his weakness, than to their own want of penetration. The mind of the emperor CLAUDIUS, for example, feeble as it was, made a subject of observation that was fortunate both for the historian and his reader. A great anatomist only can mark minute deviations in nature from her ordinary process; and, by stating slight deficiencies or excesses in certain parts, can explain irregularities that are glaring in the system.

WHEN the judgment of TACITUS operates in the way of controlling his feeling and imagination, certain failures may be detected, which are not visible when that power operates by itself. That vigour in each, which is the general cause of his excellence, renders the balance more delicate, and becomes, at times,

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the necessary cause of his defects. His errors proceed from the exuberance, not from the want of genius.

THE imagination of TACITUS had certainly got beyond due bounds, when he told us, that the redness of DOMITIAN's face was useful to him in suppressing the signs of shame. "Sævus" "ille vultus et rubor, a quo se contra pudorem muniebat *." The character of DOMITIAN was so completely abandoned, that we must suppose him destitute of every sentiment like modesty; and, at any rate, it is absurd to talk of a person thus stifling the signs of emotions of which he was actually conscious.

OUR author also speaks of the Germans as separated from the Dacians, "Mutuo metu aut montibus †." When two subjects so completely different as fear and mountains, are stated as operating in the production of one common effect, we are apt to imagine, that the historian had forgot his dignity, and aimed at a species of wit.

THE same unmeaning quaintness appears when TACITUS tells us of the confirmed jealousy that subsisted between the Lugdunenses and Viennenses. "Unde æmulatio, et invidia, et uno amne discretis connexum odium ‡." That the vicinity should insure the disagreement of these two nations is highly probable; but, in order to announce this sentiment, there was no need to go in quest of the pointed antithesis involved in the two terms *discretis* and *connexum*.

THE fact is, that the writings of PLINY, QUINCTILIAN, and the other contemporaries of TACITUS, do all carry the symptoms of declining taste. That period had arrived, at which, as the ingenious critic || before quoted observes, the writer must find means to strike and to surprise. Antithesis, remote allusions, and the double sense of words, are the tools by which he does so. In these artifices, suited to please the false taste of his countrymen,

* Vit. AGRIC. cap. 45.

† Hist. lib. 1. cap. 65.

‡ De Mor. Germ. cap. 1.

|| Bishop of Worcester.

countrymen, TACITUS was often eminently successful. Thus, in telling us, that AGRIPPINA was able to give the empire to her son CLAUDIUS, but was unable to submit to his sovereignty, he makes one word denote both the power and the absence of it. "Truci contra ac minaci AGRIPPINA, quæ filio dare imperium, tolerare imperitantem nequibat*." The verb *nequibat* is equally connected with the two infinitives *dare* and *tolerare*; but it must be decomposed, before it is applied to the first of them, so as to bring forth the historian's meaning.

FROM the charge of affectation and conceit, in certain instances, then, our author cannot be freed. It is the prerogative of criticism to censure without fear, to despise the authority of names, and to decide upon principle. TACITUS, perhaps, expected, that the lustre of his uncommon accomplishments would destroy the ridicule that is aimed at common defects; that even the luxuriant play of his genius would extort that respect which is due to its most correct productions.

MANY of the impurities that occur in the style of TACITUS are to be imputed to the times in which he lived, and not to any carelessness, or to any ignorance of his. The contemporaries of CICERO himself sometimes attacked that orator's style. From jealousy of his reputation, perhaps, they were disposed to reject even terms, "*græco fonte cadentia et parce detorta.*" In judging of the legitimacy of expression in a dead language, the most ignorant are often the most presumptuous. The influence of analogy is held to be more extensive than it is; and a high degree of uniformity is supposed to exist in a subject of all others the most eccentric. TACITUS, then, may have had authorities for those expressions which we hold to be the most irregular. From the boldness and originality of his views, at the same time, we may suppose, that he would be apt to bend the language of his country to his own conceptions, and to spurn at the fetters of strict grammatical authority.

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TACITUS,

* Ann. lib. 12. cap. 64.

TACITUS, doubtless, seems attached to expressions more commonly to be met with in writers of poetry than of prose. Expressions more simple, at the same time, might have produced an equal, if not a superior effect. By means of those Grecisms, in which he abounds, he seldom presents an idea with more energy than CÆSAR and LIVY could have done without them. Though high poetical authority often screens his style from the imputation of being impure, yet its general character becomes artificial and too much his own. When the barrenness of language, besides, does not call for innovations, the writer is blamable who makes them.

UPON examining the style of TACITUS, we shall find, that he employs some terms that are either peculiar to himself, or supported by authority not strictly classical. The term *diffugium* *, though expressive of the idea it presents, is supported by no other authority. By being compounded, it heightens the original notion of a rapid departure from an object supposed dangerous. The term *sustentaculum* † is also singular. It clearly suggests the idea of a necessary support. As a derivative from *sustento*, the frequentative from *sustineo*, it denotes the constant pressure of one body upon another immediately under it. *Auditio*, also, is a verb that is to be found in no other classic, though, at the same time, it is highly expressive of the conception which the historian means to present by it. “Qui pecunias fœnore” *auditabant* ‡.” As a double frequentative from *augeo*, it expresses strongly the eagerness of usurers to enrich themselves. The verb *restaurare*, though not peculiar to TACITUS, rests upon authority that is not to be trusted. JUSTIN and ULPIAN use it; but the purer writers employ *instaurare* in its stead.

WE may, besides, discover in TACITUS singular uses of terms that are to be seen in the works of the best classics. He takes the adjective *avarus*, and the abstract noun *avaritia*, in a sense very different

* Hist. lib. 1. cap. 39.

† Ibid. lib. 2. cap. 28.

‡ Ann. lib. 6. cap. 16.

different from what is common. The latter term is made by him to denote an article of praise in AGRICOLA as a judge. "Ubi officio satisfactum, nulla ultra potestatis persona. Tristitiam et arrogantiam et *avaritiam* exuerat *." CICERO's definition of the vice fixes the precise force of the term. "Avaritia (says he) est injuriosa appetitio alienorum." But no affection that is injurious can be meritorious in any person, far less in a judge; and the most rigid assertor of public rights cannot, in justice, invade those of individuals. Both the character and the object, then, of this *appetitio*, employed by CICERO in the definition of *avaritia*, are reversed by TACITUS. That desire which he applauds must have been more than innocent; and its objects must have been the property of that community in behalf of which AGRICOLA acted as a judge.

THE use made by our author of the adjective *avarus* corresponds entirely with the use now stated of the abstract noun *avaritia*. He tells us of GALBA, that he was, "Pecuniæ alienæ non appetens, suæ parcus, publicæ *avarus* †." The term *avarus*, in this acceptance, expresses all that insatiable thirst for possession, in behalf of the public, which the avaritious have for themselves. It denotes an inflexible keenness in GALBA to support every claim of the state he governed, in spite of those temptations to which the virtue of other emperors had yielded.

THE word *gnarus*, which is properly applicable to the person who knows, TACITUS applies to the thing known. "Gnarum id TIBERIO fuit ‡." Again, in the 45th chapter of the 12th book of the Annals, he says, "Nihil tam *ignarum* barbaris quam machinamenta et astus oppugnationum; at nobis ea pars militiæ maxime *gnara* est." SALLUST had applied the term *ignarus* to the thing unknown, as well as to the person ignorant; as, when he says, "Mare magnum et *ignara* lingua
" commercia

* De vita AGRIC. cap. 9.

† Hist. lib. 1. cap. 49.

‡ Ann. lib. 3. cap. 6.

" *commercia prohibebant* * ;" and, " *Regio hostibus ignara* †." TACITUS, who frequently imitates particular expressions of SALLUST, not only takes this seeming liberty with the compounded, but assumes a corresponding one with the radical word.

It is, by no means, common to find the word *obsidium* taken to denote, " in the way of a hostage." " MEHERDATES *obsidio* " *nobis datus* ‡." *Obsidium* properly denotes the act of investing a fortified place ; but, instead of this act, there is here substituted the manner in which a person is delivered up as a security, that a stipulation made to those who raise the siege will be performed.

BUT the irregularities in the style of TACITUS may, perhaps, appear more striking in his use of certain particles than of the terms mentioned. Let us attend, then, to his use of these four, *Alias*, *An*, *Et*, *Penes*, and observe, first, the radical power, and then the ordinary applications of each.

ALIAS, in its primary meaning, refers to an event as taking place occasionally, or at times both prior and posterior to that at which the term is used. The occasional occurrence of the event is signified when the verb appears in the aorist of the indicative ; so that the time at which the proposition is announced, is comprehended by that in which the fact affirmed takes place. Thus, " *Mutantur sæpe hominum mores, alias* " *adversis rebus, alias ætate ingravescente* §." The future existence of the event supposes the time of affirmation prior to that at which the fact is to take place, and the past supposes this posterior to that at which it actually did ; and they appear in such instances as the two following : " *Sed hæc ad te* " *scribam alias subtilius* §." " *Quibus de rebus et alias sæpe* " *nobis multa quæsitæ et disputata sunt* **."

ALIAS,

* Bell. Jug. cap. 18.

† Ibid. cap. 52.

‡ Ann. lib. 11. cap. 10.

§ Cic. de Orat.

§ Cic. Ep. ad ATT. lib. 1. cap. 11.

** Cic. Acad. Quæst. lib. 4. cap. 4.

ALIAS, then, is originally an adverb of time, and is applied indifferently to the past, the present, and the future.

UPON authority less to be trusted than that of CICERO, we find *Alias* transferred from time to place. Thus, "Idæus rubus
" appellatus est, quoniam in Ida non *alias* nascitur *." "Nuf-
" quam *alias* tam torrens fretum †."

BUT TACITUS does more than transfer *Alias* from time to place, which two furnish mutual analogies in language, by applying it to the idea of cause. Thus, when he talks of the pain which TACFARINAS's message gave TIBERIUS, "Non
" *alias* magis sua populique Romani contumelia indoluisse CÆ-
" SAREM ferunt, quam quod defertor et prædo hostium more
" ageret ‡." The circumstance of time, which, upon CICERO's authority, is the radical and the proper one, is here deserted, and the character and conduct of TACFARINAS are held forth as a cause of which the emperor's distress was the effect. We are called to attend, not to the degrees of distress which the mind of TIBERIUS had undergone, at different times, that were past, but to the comparative efficacy of the causes of its excitement. The amount of that part of the expression, then, in which *Alias* is concerned, is as if it had been stated thus:
" Non ob aliam magis quam hanc causam," nempe, " quod de-
" fertor, et prædo hostium more ageret."

THE primary power of the particle *An* is that of interrogation upon the part of some person who wishes to be informed. Thus, in TERENCE, PYTHIAS asks, " *An* abiit jam a milite?" To which CHREMES answers, " Jamdudum, ætatem ¶."

AN is sometimes employed, not for the purpose of gaining information, but for that of expressing contempt towards the person interrogated. A pretended submission is made upon the part of the enquirer, in order to bring the person interrogated to the necessity, either of condemning himself, or of being
silent.

* PLINY, lib. 24. cap. 14.

‡ ANN. lib. 3. cap. 73.

† JUSTIN, lib. 4. cap. 1. 8.

¶ EUN. lib. 4. cap. 5. 7.

silent. Thus, "*An nescis longas regibus esse manus **?" CICCERO, too, employs *An* in the same way, when he personifies his country, and makes it reason with him as to the propriety of persecuting CATILINE; "*Quid tandem impedit te? An invdiam times?*"

AN sometimes does not operate as an interrogative particle at all, but only expresses doubt, or ignorance, upon the part of the speaker. Thus SALLUST says of SYLLA, "*Multique dubitavere fortior an felicius esset †.*" So also, "*Haud scio an nemini magis quam tibi faciendum ‡.*"

UPON the best authority, then, (it should seem) *An* deviates from its original power, which is purely interrogative. It, in the first place, states a question to which no answer is expected; and, in the next, it presents the mind of the speaker as unable to satisfy itself, but, at the same time, as requiring no information from others.

TACITUS uses *An*, in the sense last mentioned, in a way that is peculiar to himself. In using it, he professes his ignorance as to the manner in which certain facts took place, but he suppresses the term that announces the uncertainty. Thus, "*ARCHELAUS finem vitæ sponte an fato implevit ||.*" He records the fact, that this king did die; and the particle *An*, besides suggesting two ways, in one of which he might have died, is, without the aid of an *incertum est*, a *dubito*, or *haud scio*, made to intimate also his ignorance, whether he perished by a voluntary or by a natural death. There is clearly hesitation upon the part of the historian, otherwise he would have been absurdly reducing all the modes of death to two, and using *An* as equivalent to *Vel*. In the same way, he talks of the seeming moderation of GERMANICUS after the defeat of the Germans, "*De se nihil addidit, metu invidiæ, an ratus conscientiam facti satis esse §.*"

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* OVID, Ep. 17. 166.

† Bell. Jug. cap. 95.

‡ Cic. de Off. lib. 3. cap. 2.

|| Ann. lib. 2. cap. 42.

§ Ann. lib. 2. cap. 22.

SOME passages in CICERO may, at first sight, seem to support that use of *An* now condemned in TACITUS. The former says, for instance, "Nos hic te ad mensem Januarium expectamus, ex quodam rumore, *an* ex literis tuis ad alios missis *." In such a case as this, however, the speaker's hesitation as to the opinion to be adopted, is but an inconsiderable circumstance. He just suggests, without wishing to remove his doubt. The expectation of seeing ATTICUS is the leading idea in the sentence; and the origin of this expectation is regarded as unworthy of the attention that is necessary to trace it. So also; "Summa senectute CATO orationem in origines suas retulit, paucis antequam mortuus est, *an* diebus, *an* mensibus †." The orator knew not whether CATO transcribed his oration a few days or a few months before his death; but, feeling that either alternative did not affect the leading circumstance, which was his great age, he only states the question which he had no desire to resolve.

IN some other passages, TACITUS uses *An* and *Sive* together, as if they were synonymous particles. He tells us, that no solicitations of PLAUTUS's friends could prevail upon him to fly from the destruction threatened by NERO. "Sed PLAUTUM ea non movere. *Sive* nullam opem providebat inermis atque exul; *seu* tædio ambiguae spei; *an* amore conjugis et liberorum, quibus placabiliorem fore principem rebatur, nulla solitudine turbatum ‡."

AN and *Sive* are analogous only when the former expresses doubt, and not when in its interrogative and ironical acceptations. With all the seeming likeness, however, that occasionally takes place between them, *Sive* requires no term to intimate doubt upon the part of the speaker, because no doubt exists. Thus, LIVY tells us, "Tum dictator cenfuram minuere parat: *seu* nimiam potestatem ratus, *seu* non tam magnitudine honoris quam diuturnitate offensus ||."

* Cic. Ep. ad ATT. lib. 1. cap. 2.

† Ann. lib. 14. cap. 59.

‡ Cic. in BRUTO, 89.

|| Liv. lib. 4. cap. 24.

AN and *Sive* agree in suggesting ignorance in the speaker in respect to the suitability of an affirmation, applicable to one of two or more alternatives, to the exclusion of the rest. But *An* supposes, that something, though not enough, is known with regard to each of the whole. Thus, they who doubted whether SYLLA owed most to his valour or his good fortune, possessed facts that tended to establish both opinions, though neither preponderated. The mind is thus exhibited as balancing circumstances, and terminating in doubt from the scantiness of that information which *An*, as an interrogative, serves originally to furnish. *Sive*, again, supposes complete ignorance as to all the alternatives stated, so as to preclude that doubt, of which the act of balancing probabilities is the sign. In the case of *An*, (we have found), something is known with respect to all of them; in the case of *Sive*, nothing is known in respect to any one; and the whole subject is held forth as either, in its nature, inscrutable, or as industriously and effectually concealed. Thus TIBULLUS says;

*Vivite felices, memores et vivite nostri
Sive erimus, seu nos fata fuisse velint* *.

TERENCE also says;

— *Hæc* ANDRIA

Sive ista uxor, seu amica est, gravis e PAMPHILO est †.

In the first of these instances (it is clear) that heaven only could know which of the alternatives was to take place; and, of course, the matter was inscrutable. In the second, DAVUS virtually acknowledges, that he was not so much in the young man's confidence as to know whether he was married or not; and, of course, that matter, though perhaps known to others, was effectually concealed from him.

If the account given of *An* and *Sive* be just, TACITUS is singular, either in taking them as synonymous particles, or in employing

* Lib. 3. el. 5. 31.

† AND. act. 1. sc. 3. 11.

ploying the former in such a way as to lead his reader, in the instance quoted, to suppose, that the truth of the last alternative might have been explored, while that of the two former was incapable of being so. All the three appear to be equally the subjects of conjecture. By changing the particle, the historian meant, perhaps, to insinuate, that he reckoned the last cause the most probable; and it was, at least, worthy of his candour, to ascribe most probability to that which was most for the honour of PLAUTUS.

That TACITUS had some such purpose in view, by changing the particle, may be inferred from a similar passage, in which, after employing the *Sive* twice, he lays hold of the conjunction *Vel*. "Agitasse LACO, ignaro GALBA, de occidendo TITO VERNIO dicitur, *sive* ut pœna ejus animos militum mulceret, *seu* conscium OTHONIS credebat, ad postremum *vel* odio*." LACO's purpose is represented as arising from one of three motives; but the two first are not to each other as both are to the third. The historian knew not whether it sprang from wishing to do what was agreeable to the soldiers, or from jealousy of an undue attachment to OTHO; but he affirms, that, if from neither of these, it certainly sprang from hatred.

TACITUS employs the conjunction *Et* as synonymous with *Cum*, and as expressive of time. He says, "Nondum quartus a victoria mensis, *et* libertus VITELLII vetera odiorum nomina æquabat†." Though this use of *Et* may be subservient to the purposes of description; yet, from its novelty, it must be regarded as a grammatical licence. The will of the speaker is, indeed, absolute, in uniting by this, and other conjunctions, what objects it pleases; yet a certain degree of similarity is expected in those that form the assemblage. *Et* is here made to unite a period of time and a state of political corruption; and the writer's intention is to mark the rapidity of the growth of the latter, by conjoining, and, of course, contrasting it with

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* Hist. lib. 1. cap. 39.

† Ibid. lib. 2. cap. 95.

the shortness of the former. Such uses of *And* in English, and *καί* in Greek, are frequent; but an instance precisely similar to that mentioned will hardly be found in Latin.

THE use which TACITUS makes of the preposition *Penes* is not to be justified by any good authority. He tells us, that TIBERIUS was offended because the practice of marrying by the *Confarreatio* had fallen into disuse. “Pluresque ejus rei
“causas adferebat; potissimam *penes* incuriam virorum femi-
“narumque*.”

THE preposition *Penes* denotes the relation which an object bears to a person, as being in his power and under his direction †. Thus,

Me penes est unum vasti custodia mundi ‡.

A CERTAIN vicinity is supposed to exist between the master and that which is subject to his dominion. Within a limited sphere, accordingly, he is understood to have the merit of what is laudable, and the demerit of what is the contrary. So, “*Penes aliquem laudem esse* ||;” and, “*Illorum esse hanc culpam credidi quæ te est penes* §.” The term *illorum*, in the last instance, denotes the relation between the blame, and a number upon whom it was not chargeable; but the term *Penes* denotes the relation between the blame, and one at whose door it actually lay, as being in a sphere within which that person had an exclusive right to exercise authority.

IN the expression, “*potissimam penes incuriam virorum feminarumque*,” the preposition is evidently employed, as in the passage quoted from TERENCE, to state the relation between

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* Ann. lib. 4. cap. 16.

† I MIGHT here state the precise meaning of *Penes* at greater length, by shewing the difference between it and *Apud*, with which it is sometimes confounded; but I reserve an analysis of the Latin prepositions as the subject of future consideration.

‡ OVID, Fast. I. 119.

|| CIC. de Cl. Or. 142.

§ TER. HEC. act. 4. sc. 1. 20.

a certain degree of blame, and the persons supposed culpable. The idea of blame in TACITUS, however, is got by implication; that is, from knowing that TIBERIUS disapproved of the modes of marrying by the *Coemptio* and the *Ufus*, which were different from that before mentioned. The word *incuria*, besides, which expresses the carelessness, that is, the culpable circumstance, is under the government of the preposition, instead of being a correlative term to those expressing the persons upon whom the blame is laid. This word, also, as denoting only the absence of thought, is too specific to act as a correlative to those denoting the persons. In proportion as the power of the noun is, in this situation, more than ordinarily particular, that of the preposition becomes more than ordinarily general. The latter is not limited to the conception of blame in agents, as usual, but denotes the relation between one object and another, acting as its immediate cause, and may be translated "owing to." Had the general term *culpa* been used, the expression "penes viros feminasque" would have been legitimate; but the "causa penes incuriam virorum feminarumque" is certainly singular.

If we had leisure to examine the modes of construction in TACITUS, as minutely as we have the terms, the former, perhaps, would, on some occasions, appear as singular as the latter. He sometimes puts a genitive after a verb that usually governs an accusative. "Nihil abnuentem dum *dominationis* apifce-
"retur*." We find, also, an accusative coming after a verb, which other writers make govern a dative. "*Sua facinora* ad-
"versari deos lamentantur†. The verb *præfideo*, besides, is sometimes made to govern a dative, as usual, and, at other times, an accusative, which will hardly be seen in any other author. "Præfidere *ludis* ‡." "Præfidere *Pannoniam* ||."

TACITUS

* Ann. lib. 6. cap. 45.

† Ibid. lib. 3. cap. 64.

‡ Ibid. lib. 1. cap. 28.

|| Ibid. lib. 12. cap. 29.

TACITUS, also, often imitates SALLUST, in adopting uses of terms, and modes of construction, that are properly Greek. Thus, "Memoriæ Drusi eadem quæ in Germanicum decernuntur, plerisque additis ut ferme *amat* posterior adulatio *." As the Greek verb φιλεω often denotes ordinary and natural occurrence in certain cases, so does the Latin verb *amo* here.

— Φιλεει δε τε κερτομα βαζειν †.

— *Amatque convicia loqui.*

So also, "Οπερ εν τοις τοιςτοις φιλει." The attachment to a specified action, suggested by the two verbs in the different languages, is made to denote its frequency even among inanimate objects. TACITUS also suppresses the governing preposition, after the manner of the Greeks. Thus, as they said, "Ρωμαιος πατριδα," for "Ρωμαιος κατα την πατριδα;" so he frequently adopts such poetical expressions as, "Clari genus ‡," "Animum vultumque" "conversi ||."

FROM the view now taken of the style of TACITUS, it should seem, that it will not bear a comparison with that of the writers during the reign of AUGUSTUS. The age of high classical purity was, in his days, past; and, of course, the grammatical standard established by practice had altered. As the wish of our author must have been to please his contemporaries, so he would naturally adopt those modes of expression that were most agreeable to them; and we cannot suppose him able, though he had been disposed, to resist that progress towards corruption which had already commenced. The impurities of his style, at the same time, can never cancel the dignity of his sentiment. In the one, we see the Roman language, in some degree, corrupted; but, in the other, we see human reason proportionably improved.

THE

* Ann. lib. 4. cap. 9.

† Ann. lib. 6. cap. 9.

‡ HESIOD. Ep. 5. 788.

|| Hist. lib. 1. cap. 85.

THE character of TACITUS as an historian, though, upon the whole, deservedly high; yet cannot, in every respect, escape our censure. He possessed powers perfectly adequate to the task of speculating upon the affairs of men, as becomes a philosopher. His sensibility caught those delicate shades in the human character, of which ordinary observers lose sight amidst its great outlines. His fancy suggested the precise emotions most likely to arise in a trying situation; led him to adopt that language by which such emotions seek vent; and to seize the circumstances, in every object described, which strike the observer first, and bring the rest along with them. His judgment discriminated the genuine from the spurious, however artfully embellished; and, in the action even of complicated causes, could assign the exact influence of each in the production of their common effects. But the ardour of his feeling, and the quickness of his fancy, sometimes betrayed him into errors. Strong as his judgment was, it did not always watch and control their excesses. The elegance of his style and sentiments, accordingly, degenerates, at times, into affectation, and their animation into extravagance. From the general vigour of his powers, he has thrown beauties into many passages which few writers, in any age, have rivaled, and which none have surpassed; but, from an undue balance, occasionally existing among these powers, certain passages are overwrought, and deformed by those attentions that were meant to improve them.

SHAKESPEARE and TACITUS are, perhaps, the two writers who leave upon the minds of their readers the strongest impression of the force of their genius. Splendid beauties in each are but eclipsed by faults which would have cancelled the merit of ordinary performers. We should, indeed, have no standard for measuring their excellence, did not the poet sometimes shock us with his extravagancies, and the historian with his conceits.

THE

THE opinions of the best modern critics confirm the favourable judgment given upon the writings of TACITUS. They were rated beneath their value by those who pretended to judge of them in the last century. Mere philologists might, indeed, detect impurities in our author's style, and falsely ascribe that obscurity to a fault in his diction, which, in fact, had its seat in the depth of his thought. Being void, however, of that science which alone makes literature respectable, no words could unfold to them those beauties upon which he meant that his reputation should rest. Monsieur D'ALEMBERT*, and other French critics, whose merit entitled them to direct literary opinions, saw the value of his works, and removed, in some degree, the prejudices that had subsisted against them. The elegant Mr GIBBON tells us, "That, if we can prefer personal merit to accidental greatness, we shall esteem the birth of the emperor TACITUS more truly noble than that of kings: "That he claimed his descent from the philosophic historian, "whose writings will instruct the last generations of mankind†." That the emperor did not feel himself dishonoured by the connection, appears from his giving orders, that ten copies of TACITUS should be annually transcribed, and placed in the public libraries. From the works of his immortal ancestor, he expected, that his subjects would learn the history, not of the Roman constitution alone, but of human nature itself. By rescuing even a part of these from destruction, he acquired a right to the gratitude of posterity; because he thereby preserved a mine, in which, the longer and the deeper we dig, we shall find the richer ore.

HOWEVER feeble this attempt to trace the principles of historical composition may have been, it may perhaps shew, that TACITUS, and all successful historians, have pleased, not by accident, but by rigidly adhering to a standard which they

* *Melanges de Litterature*, tom. 3. *Morceaux de TACITE*.

† *Hist.* vol. 1. p. 325.

they must have previously discerned. In spite of those diversities in point of manner, and gradations in point of merit, which necessarily take place among a number of writers, the leading characters of this standard must be the same to them all. A new proof may be thus had, that there is as certainly, in the nature of things, an immutable difference between beauty and deformity, as between truth and falsehood; that the principle of taste is more consistent in its decisions than is generally supposed; and that, in all the fine arts, this principle is gratified when we observe, and offended when we neglect, certain laws which are the basis of just execution, and of sound criticism in each.

END OF THE FIRST VOLUME.

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THE BRITISH MUSEUM
NATURAL HISTORY
DEPARTMENT
The following is a list of the
specimens of the genus
which have been deposited
in the collection of the
British Museum, and which
are now in the possession
of the British Museum.
The specimens are arranged
in the order of the
genera, and the names of
the authors are given in
the margin of the list.
The list is arranged in
the order of the genera,
and the names of the
authors are given in the
margin of the list.



E R R A T A.

Phys. Cl. page 213. line 5. for *vis incita* read *vis insita*.

————— 314. line 4. from the bottom, for greater read less.

————— 324. The Author finds, on resuming the computations, that the error in latitude is but half a minute. Since this article was printed off, he has seen, in the *Memoirs of the Academy of Berlin*, *Elements of this Orbit*, by P. FIXLMILNER, and a comparison of them with a great number of Observations. There is some mistake in this article of the *Memoirs*; for the mean distance and diurnal motion set down in those *Elements*, are inconsistent with each other, and both of them are incompatible with the Observations. The Author will just observe, that the form of the Ellipse is precisely the same with that deduced by him from the second supposition respecting the second differences of the arches, and mentioned at the bottom of p. 322.

————— 327. Tab. I. col. 3. line 2. for 10. 23. 06. 26 read 11. 23. 06. 26.

————— 332. Tab. V. col. 1. lines 14, 15. for 01. 02 read 10. 20.

Lit. Cl. page 116. line 16. for And to read And as to

————— 119. The four first lines of the note should be a separate note on page 123. taken off at the end of the 2d paragraph, at the word presupposes.

————— 206. Note †, for Ep. read Egv. and *ipse*.

DIRECTIONS FOR THE BINDER.

The Binder is desired to observe that the Vol. consists of Three Sets of Pages, to be arranged in the following order, immediately after the TABLE of CONTENTS, viz. PART I. containing THE HISTORY OF THE SOCIETY: PART II. containing, I. PAPERS OF THE PHYSICAL CLASS; II. PAPERS OF THE LITERARY CLASS: And to place the two Plates, entitled *Theory of the Earth*, to front page 304. of Papers of the Physical Class, and the other Plates (which fold out) according to the references marked upon them.